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GOLD

By John M. Lucas

1989

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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GOLD

U.S.
DEPARTMENT
OF THE
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Secretary

BUREAU
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Director

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COVER PHOTO

Vietnam tael wafer bar. Paper-thin note of pure gold measuring about 3.1 cm (1⅛ inches) by 9.8 cm (3⅞ inches). Easily valued by weighing and highly concealable, this type of note has reportedly served as a form of hard currency throughout Southeast Asia for more than a century. (Photo is courtesy of World Coin News, Iola, WI. 54990.)

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GOLD

By John M. Lucas

Mr. Lucas, a geologist with 29 years of Federal, State, and foreign and domestic mineral industry experience, has been the Bureau of Mines commodity specialist for gold since 1980. Domestic survey data were prepared by Eraina C. Dixon, Lisa P. Conley, and Stephen L. Hays, Nonferrous Data Section. International data tables were prepared by Giovanni P. Jacarepaqua, International Data Section.

Gold production by the domestic and international mining industry continued at record levels during 1989. With production rising more than 33% over that of 1988, the domestic industry completed its 10th successive year of growth. Nevada continued as the Nation's principal gold-producing State, having increased production nearly twentyfold since 1979. The overall demand for gold for use in fabricated products in the market economy countries exceeded the record level set in 1988. Jewelry was again the dominant end-use sector. Hoarding of gold bars, exclusive of North America and Europe, surpassed the record level reached during the previous year.

LEGISLATION AND GOVERNMENT PROGRAMS

On June 14, under legislation approved in 1988, gold and silver coins commemorating the Bicentennial of the U.S. Congress (1789–1989), were struck on four 7-ton coin presses mounted temporarily in front of the U.S. Capitol. The ceremony marked the first time since 1792 that official U.S. coins were struck outside of a U.S. Mint facility. The enabling legislation provided for surcharges from the sale of the coins to go to the U.S. Capitol Preservation Commission to maintain and restore the Capitol. Up to 2,239 kilograms (72,000 ounces[1]) of gold and 33,090 kilogram (kg) (1.064 million ounces) of silver will be used in minting the coins.

In 1989, legislation affecting gold was enacted by a number of States. Laws regulating the use of cyanide in gold and other mineral processing operations were enacted in Montana and South Dakota. A new Montana law requires that small placer or dredge mining operations that disturb 0.8 or more hectares (2 or more acres) must comply with the State's general mine reclamation requirements. In a special election held in May, Nevadans approved a tax on gold mining. The measure amended the State constitution and increased the net profits tax on all mineral production from about 2% to 5%. In June, the Governor of Nevada signed into law that State's first program for reclamation of mined lands. The law requires that all public and private lands disturbed by mining or exploration activities be reclaimed in an economically and technically practical manner to a safe, stable condition capable of supporting a productive postmining land use.

A law exempting the sale of precious metal bars and bullion coins from a 4% State sales tax became effective in New York on September 1. To be eligible for the exemption, the sale must be for $1,000 or more, with the price being based on the item's metal content, not its aesthetic value. Coins produced by the Republic of South Africa, with coins and bars produced for noninvestment purposes, were not eligible for the exemption. Texas and Ohio passed similar legislation during 1989.

In June, the U.S. Forest Service announced that, effective May 1, 1990, it will require certification of its examiners who investigate and evaluate unpatented mining claims located on National Forest System lands. Under the certification program, mineral examiners will have to be mining engineers or geologists and have had training in mineral examination, experience in mining claim validity examinations, surface use determinations, or mining law-related actions. The new certification process pertains only to Forest Service employees. Private mining consultants wishing to perform mineral examinations on the National Forest lands will have to meet the same qualifications as a Certified Forest Service Mineral Examiner before being awarded a contract to work on National Forest System land.

STRATEGIC CONSIDERATIONS

Gold is not a National Defense Stockpile item; however, the Treasury had stocks of bullion amounting to about 8,146 metric tons (262 million ounces) at yearend 1989. Large quantities of gold are also held as commercial and private bullion stocks. Therefore, the availability of gold in times of national emergency appears to be ensured.

One strategic aspect of the domestic gold mining industry that is infrequently considered is that the industry constitutes a valuable pool of experienced personnel, including chemists, geologists, engineers, and metallurgists as well as miners, machinists, and heavy equipment operators. In the event of a national emergency, these skills may be readily directed toward the discovery, development, and production of strategic materials.

PRODUCTION

Of the 266 metric tons of gold (8.5 million ounces) produced in the Nation, 75% was attributed to the 25 leading producers. The average recoverable gold content of precious metals ores processed from lode mines was 1.37 grams per metric tons (0.04 ounce per short ton), while placer gravels yielded an average of 1.23 grams per cubic meter (0.03 ounce per cubic yard) of material washed.

The individual company production and performance data in this chapter

TABLE 1

SALIENT GOLD STATISTICS

		1985	1986	1987	1988	1989
United States:						
Mine production	kilograms	75,495	116,297	153,870	200,914	265,541
Value	thousands	r$771,035	r$1,376,860	$2,216,026	$2,831,281	$3,266,208
Percentage derived from:						
Precious metal ores		92	96	91	W	W
Base-metal ores		5	2	6	W	W
Placers		3	2	3	2	2
Refinery production:						
Domestic and foreign ores	kilograms	64,583	75,618	112,368	137,829	183,685
Secondary (old scrap)	do.	49,824	47,266	63,843	52,807	36,895
Exports:						
Refined	do	89,837	110,555	71,177	271,335	123,599
Other	do.	33,541	44,810	48,453	56,902	87,492
Imports for consumption:						
Refined	do.	197,849	429,242	75,365	57,590	96,967
Other	do.	58,008	60,621	44,174	r34,867	55,537
Gold contained in imported coins[1]	do.	64,198	34,245	33,716	[2]17,947	[2]13,218
Net deliveries from foreign stocks in Federal Reserve Bank	do.	15,054	145,938	95,146	208,277	132,231
Stocks, Dec. 31:						
Industry[3]	do.	18,538	28,771	23,390	r38,360	24,828
Futures exchange[4]	do.	65,628	87,370	81,647	44,634	69,727
Volume of U.S. Gold Futures Trading[5]	metric tons	24,723	26,365	33,100	29,920	31,330
Department of the Treasury:						
American Eagle gold coin sales	kilograms	—	(6)	[7]82,704	[7]17,416	[7]16,544
Bicentennial of the U.S. Congress[8]		—	—	—	—	1,508
Bicentennial of the U.S. Constitution coin sales	do.	—	—	(9)	[10]6,463	—
U.S. 1988 Olympic coin sales[11]	do.	—	—	—	2,477	93
Consumption in industry and the arts	do.	96,318	97,234	100,566	r97,842	98,742
Price:[12] Average per troy ounce		$317.66	$368.24	$447.95	$438.31	$382.58
Employment[13]		6,900	8,300	11,100	13,100	15,000
World:						
Production, mine	kilograms	1,531,858	1,602,215	1,658,142	p1,847,840	e1,971,004
Official reserves[14]	metric tons	35,616	35,625	r35,563	35,763	35,538

e Estimated. p Preliminary. r Revised. W Withheld to avoid disclosing company proprietary data.

[1] Calculated by the Gold Institute from reports by the Bureau of the Census.

[2] Beginning 1988 net imports (exports).

[3] Unfabricated refined gold held by refiners, fabricators, dealers, and U.S. Department of Defense.

[4] Commodity Exchange Inc. only. Stocks held by other exchanges estimated to be less than 2% of totals shown.

[5] Exchanges: Commodity Exchanges Inc., Chicago Board of Trade International Monetary Market (1987–88 only), and Mid-America Commodity Exchange.

[6] Sales program began on Oct. 20, 1986; sales adjusted and included in 1987 total.

[7] Fiscal year begins Oct. 1 of previous year indicated.

[8] Sales program began June 14, 1989.

[9] 1987 sales included in 1988 based on fiscal year beginning Oct. 1.

[10] Total sales, program began July 1, 1987, and ended June 30, 1988.

[11] Sales program began Feb. 15, 1988; completed June 3, 1989.

[12] Engelhard Industries quotation.

[13] Mine Safety and Health Administration.

[14] Held by market economy country central banks and governments and international monetary organizations. Source: International Monetary Fund.

including the references cited at the end of this report were derived from published sources such as company annual reports.

TABLE 2

MINE PRODUCTION OF GOLD IN THE UNITED STATES, BY STATE

(Kilograms)

State	1985	1986	1987	1988	1989
Alaska[1]	1,391	1,501	3,812	4,210	5,756
Arizona	1,619	W	1,791	4,549	2,810
California	5,842	13,238	18,277	22,442	29,804
Colorado	1,347	3,743	5,561	5,126	3,448
Idaho	1,378	2,191	3,041	3,218	3,057
Michigan	W	W	W	W	W
Montana	4,985	W	7,143	9,175	11,623
Nevada	39,692	r65,330	83,342	114,322	154,573
New Mexico	1,401	1,240	W	W	1,076
North Carolina	—	(2)	—	—	—
Oregon	W	W	W	W	W
South Carolina	W	W	W	W	W
South Dakota	11,076	W	W	13,981	16,123
Utah	4,214	W	W	W	W
Washington	W	W	W	W	W
Total	75,495	116,297	153,870	200,914	265,541

r Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] These figures, reported to the Bureau of Mines, probably understate production. Data collected by the State indicate production to have been as follows, in kilograms: 1985—5,910; 1986—4,977; 1987—7,154; 1988—8,242; and 1989—9,265.

[2] Less than 1/2 unit.

Alaska

Gold was the most valuable mineral product, accounting for 39% of total mineral production revenues. According to a Summary of 1989 Mineral Activity prepared by the Alaska State Div. of Geological and Geophysical Surveys (DGGS), gold production was reported from 222 operations; 217 placer mines and 5 lode mines.[2] The total number of operations in 1988 according to DCGS was 211. Gold production in Alaska of 5,756 kg (185,055 ounces) was reported to the Bureau of Mines by 17 operations. However, an informal annual survey by the DGGS suggested that 9,265 kg (297,900 ounces) was produced.

Alaska's largest gold producer in 1989, the Valdez Creek Mining Co.'s placer operation east of Cantwell, produced 2,237 kg (71,942 ounces) of raw unparted gold during the 1989 operating season. The Alaska Gold Co. operated its two onshore gold dredges at Nome while offshore of Nome Western Gold Exploration and Mining Co. Ltd. Partnership (WestGold) recovered about 899 kg (29,000 ounces) of gold with its mining vessel, the *BIMA*.

Five lode mines reporting production during the year were: the new Greens Creek Mine near Juneau, the State's second largest gold producer, the Ryan Lode Mine, the Grant Mine, and the Democrat Mine, all located near Fairbanks, and the old Independence Mine near Hatcher Pass.

Following a trend established in recent years, funds expended by corporations exploring for precious metals accounted for nearly 92% of the $46 million spent in 1989. Of funds expended, 59% was on three advanced gold exploration projects: the Fort Knox Mine project of Fairbanks Gold Ltd. near Fairbanks and Echo Bay Mines Ltd.'s two advanced projects—the rejuvenation of the old A–J Mine at Juneau and the Kensington Mine project at Berners Bay, 80 km (50 miles) north of Juneau.

The relaxation of tensions between the U.S.S.R. and the United States resulted in an exchange during 1989 of visits by scientific personnel from both countries. Gold Mines in the Magadan Oblast region of neighboring Siberia were visited by personnel from the Bureau of Mines and by representives from Alaskan State, educational, and industrial organizations.[3]

A brochure on Placer Mining in Alaska prepared by the U.S. Bureau of Land Management was published in 1989. The brochure provided an overview of placer mining methods used on public lands in Alaska and offered suggestions for avoiding or reducing the environmental effects of placer mining and for reclamation of placer mining sites.[4]

Arizona

At Arizona's largest gold mine, Cyprus Gold Co.'s Copperstone Mine near Quartzite in LaPaz County, underground development was suspended because lower ore grades were encountered. However, the company continued the open pit operation. Copperstone had a productive capacity of nearly 2,200 kg (70,000 ounces) per year.

Several mines produced gold-bearing flux ore that was shipped directly as a flux to copper smelters where the gold values were ultimately recovered as a byproduct of copper refining.

After less than 1 year of operation, mining at the McCabe Mine in Yavapai County was halted in early 1989. The owner, Stan West Mining Corp., later transferred ownership of the facility to Elders Resource Finance Inc. of Australia.

Exploration for gold continued to be widespread throughout Arizona. Exploration accompanied by drilling was conducted at a number of properties, including the following: the Yarnell Mine in Yavapai County by joint-venture partners ASARCO Incorporated and Norgold Resources Inc. and the Mexican Hat property in Cochise County by venture partners Placer Dome U.S. Inc. and Oneida Resources Inc. Other sites included DRX Inc.'s Commonwealth property and Queenstake Resources Ltd.'s Gold Prince Mine, both in Cochise County; and East West Minerals Inc. at the Clementine Mine, U.S. Borax and Chemical Corp. at the Picacho project, and Westmont Mining Inc. and Aur Resources Inc. at the Newsboy deposit, all in Maricopa County.

California

For the third consecutive year, California has ranked as the Nation's second largest gold-producing State. Three California gold mines, McLaughlin, Mesquite, and Jamestown, were among the top 25 gold producers during 1989.

The McLaughlin Mine of Homestake

Mining Co., located about 113 km (70 miles) north of San Francisco, produced a record 8,823 kg (283,843 ounces) of gold during 1989. A new oxide ore processing circuit commissioned in early 1989 and new cost control measures initiated during the year combined to improve productivity and led to an increase in production of 2,489 kg (80,016 ounces) over that of 1988. California's second largest gold mine, the Mesquite Mine owned by Gold Fields Mining Corp., recovers about 5,750 kg (185,000 ounces) annually using heap leaching. Gold ore, mined from several surface deposits at the Imperial County site, was processed and stacked on the heaps at a rate of about 18,000 metric tons per day.

Improved gold recovery and higher throughput of ore contributed to an increase in gold production to 3,461 kg (111,300 ounces) in 1989 at the Jamestown Mine in Tuolumne County. The large surface mine opened in late 1986 by Sonora Gold Corp. employed flotation methods to produce a gold concentrate. The concentrate was processed for gold recovery at the Buckskin leach plant at Yerington, NV.

Several new mines began production in 1989, and several others were closed. The new Royal Mountain King Mine near Copperopolis, Calaveras County, began open pit mining and milling in February. This new mine, owned by Meridian Gold Co. and Mother Lode Gold Mines Consol., was expected to recover about 1,866 kg (60,000 ounces) of gold annually. In September, the American Girl Mining Corp. poured the first gold at its new open pit heap leaching American Girl Canyon Mine in Imperial County. The Carson Hill Mine at Angels Camp, Calaveras County, closed in October. Leaching of previously mined ore and site reclamation were proceeding at yearend. The Sixteen-To-One Mine in Sierra County was placed on a care-and-maintenance status late in the year.

In September, Bond International Gold Inc. sold its 67% interest in the Yuba dredge placer operation near Marysville, Yuba County, to WestGold. Yuba dredge reportedly recovered 732 kg (23,540 ounces) gold during the fiscal year ending June 30, 1989.

While a dozen or more other mines continued to produce gold in California, other properties undergoing exploration or moving toward production included the following: Viceroy Resources Corp.'s Castle Mountain property in San Bernardino County, Amax Gold's Hayden Hill property in Lassen County, Centurion Gold Ltd.'s Grey Eagle Mine and American Gold Mineral Inc.'s Siskon Mine in Siskiyou County, and the Long Valley prospect of Royal Gold Inc. and Standard Industrial Minerals Inc. in Mono County.

Colorado

A nearly 33% decline in gold production from the previous year reflected to some extent the closure of two mines and the failure of several new mines to reach production.

The principal producing gold mines were the Summitville Mine in Rio Grande County, the Sunnyside Mine at Silverton, and the combined operations of the Cripple Creek and Victor Mining Co. in Teller County. Several other smaller producers such as the Bessie G Mine in La Plata County were also active during the year.

Mining at Galactic Resources' seasonal Summitville Mine was halted in mid-June following the discovery of an unstable area in the embankment of the leach pad. About 170 employees were laid off and studies to remedy the leach pad problem were initiated. Leaching of previously mined ore continued, and nearly 1,000 kg (32,000 ounces) of gold was recovered. More than twice that amount was recovered during the previous year.

Underground mining operations at the Sunnyside Mine in San Juan County were continued by the mine's operator and owner of a 33% share, Washington Mining Co. Gold production during the year declined about 5% from that of the previous year to about 921 kg (29,612 ounces).

In Teller County, Cripple Creek and Victor Gold Mining Co. recovered nearly 1,100 kg (34,507 ounces) of gold from its Mine Dump Rock and Gold Star Projects and its Portland open pit. Mining of the Portland pit was completed and reclamation of the affected area was being planned at yearend. The company reportedly had several new local exploration projects under study.

Battle Mountain Gold Co. decided in early 1989 to modify its mining plan at its developing San Luis project in Costilla County and thereby limit gold recovery to milling only rather than milling and heap leaching combined. The decision necessitated the amendment of the company's mining permit and was expected to delay the targeted startup until early 1991. The San Luis project was expected to yield about 1,870 kg (60,000 ounces) of gold per year for at least 8 years.

The Empire (Grace) Mine project that was expected to produce in 1989 was further delayed while the owner, Nevada Goldfields Corp., negotiated a joint venture for further exploration and development. The proposed open pit heap-leaching project is located in Clear Creek County about 64 km (40 miles) west of Denver.

Exploration and development was continued at a number of other Colorado gold properties, including the Platoro gold-silver mine in Conejos County, Levon Resources Ltd.'s Carbonate Hill property in Teller County, and Hendricks Mining Co.'s Cross Mine, an underground mine at Caribou in Boulder County.

Idaho

The number of active exploration projects in Idaho, dominated by interest in precious metals, increased from 68 in 1988 to 82 in 1989 according to a review of State mineral activities prepared by the Idaho Geological Survey.[5] The State defined an active project as one that had some significant work such as sampling and trenching or drilling, not just claim staking.

Despite the heightened level of exploration that may eventually lead to increased production, total Idaho gold production during 1989 remained near the level achieved during the previous year. Producing gold mines in Idaho during 1989 included Nerco Minerals Co.'s DeLamar Mine in Owyhee County, Pioneer Metals Corp.'s Stibnite-West End and Coeur d'Alene Mines Corp.'s Thunder Mountain Mine, both in Valley County, and Idaho Gold Corp.'s newly opened Champagne Mine in Idaho County. All of these properties were open pit heap-leaching operations, except that DeLamar also employed a vat-leaching recovery system.

Nerco announced that it had begun development of its Stone Cabin deposit, formerly referred to as Florida Mountain. Stone Cabin is adjacent to the DeLamar Mine. The property, reportedly containing more than over 18,000 kg (580,700 ounces) of recoverable gold, was to be developed as a satellite opera-

tion of the DeLamar Mine with mining projected to begin by early 1992. Nerco also signed an agreement with War Eagle Mining Co. Inc. to explore War Eagle's claims on War Eagle Mountain about 6.4 kilometers (4 miles) east of Nerco's DeLamar property.

Hecla Mining Co.'s Yellow Pine unit in Valley County did not operate during the 1989 season. Instead, a new $4.5 million heap-leach facility was constructed. Startup of the new plant was scheduled for the second quarter of 1990 with an anticipated seasonal output of about 1,900 kg (60,000 ounces). U.S. Antimony (USAC) continued to process ore from its various mining operations at its mill at Preacher's Cove in Lemhi County. The company signed joint-venture agreements with WestGold to further explore USAC's Yellow Jacket Mine and Estes Mountain property, both in Custer County.

Grouse Creek Mining Co., a subsidiary of CoCa Mines Inc. of Denver, moved ahead with development of its Grouse Creek deposit and newly acquired Sunbeam property on nearby Jordan Creek in Custer County. A new milling process was devised that would work with both deposits as well as address concerns of environmentalists. A conventional milling technique with zero discharge was selected and should be operational by 1992.

Interest in the potential for further gold discoveries in the Salmon area in Lemhi County, Southwestern Idaho, were heightened by the 1988 discovery by Meridian Minerals Co. of their large Beartrack deposit. Among the companies reported by the State to be exploring in the Salmon area during the year were AMAX, American Gold Resources Corp., Corona Gold Inc., FMC Gold Corp., GEXA Gold Corp., Hecla, Homestake, Placer Dome, Sovereign Explorations Inc., and many others.

Michigan

In early October, Callahan Mining Corp. of Phoenix, AZ, announced that its Ropes gold mine, near Ishpeming, MI, the Nation's only underground gold mine east of the Mississippi, had been shut down indefinitely owing to the low price of gold and ground control problems near the main production shaft. Nearly 550,000 metric tons of ore bearing 2.33 grams per metric ton (0.069 ounce per short ton) was hoisted and milled during the 9-month period prior to closure.

Montana

Mining and mineral developments in Montana during the year were summarized in a report prepared by the Montana Bureau of Mines and Geology.[6] The number of mining plans, most of which included gold, filed with the U.S. Forest Service increased from 246 plans in 1988 to nearly 400 in 1989. Similarly, mineral exploration, again focused primarily on gold, continued to expand. The State reported that 35 new State exploration permits were issued during the year, bringing the total to 210 compared with 192 in 1988 and only 56 in 1982. All mining activity in Montana, whether on private, State, or Federal land, is regulated by the Montana Department of State Lands. Exploration, including drilling, sampling and mapping, was continued at many properties throughout the mineralized areas of the State, and some properties were moved a step closer toward development and production.

Gold production from Montana's active mines increased 27% over the previous year, reflecting in part, improved performance at some operations plus the contribution of newly opened mines, including the Beal Mountain Mine and the Mineral Hill Mine.

The new Mineral Hill Mine at Jardine in south-central Park County opened in September. Mineral Hill, an underground operation and joint venture of American Copper and Nickel Co. and Homestake, was initially expected to produce about 1,300 kg (42,000 ounces) annually.

In June, Pegasus Gold opened its new open pit Beal Mountain Mine at German Gulch Southwest of Butte, Silver Bow County. The new heap-leaching operation was designed to produce nearly 1,100 kg (35,000 ounces) per year over a mine life conservatively estimated at 10 years. Pegasus also operates three other large gold mines in Montana: the Zortman/Landusky Mine in Phillips County; the Montana Tunnels gold, silver, lead, and zinc mine in Jefferson County; and the Basin Creek Mine, formerly known as the Pauper's Dream Mine, in Lewis and Clark County. Other principal gold-producing mines in the State include Placer Dome's Golden Sunlight mine in Jefferson County near Whitehall, the Kendall Mine of Canyon Resources Corp. near Lewistown, and Blue Range Mining Co.'s Geis Mine, both in Fergus County. Operations at another Fergus County mine, the Spotted Horse, were suspended during the year, reportedly for economic reasons.

Numerous, generally small, intermittent placer operations were active along favorable drainages in Western Montana. In September, Highland Gold Properties Inc., working their placer claims in Cooley Gulch on the Fish Creek drainage in Silver Bow County, recovered an 855 gram (27.495 ounce) nugget; reportedly the largest gold nugget found in Montana during this century.

Nevada

Nevada's percentage contribution to the Nation's total gold production increased yet again over that of the previous year. Fifteen of the Nation's leading 25 gold mines during 1989 were located in Nevada.

Newmont Gold Co. (NGC), with operations generally centered in Eureka and Elko counties near the town of Carlin, was once again the largest gold producer in Nevada as well as in the Nation and in North America. As the largest producer, NGC also controlled the Nation's largest block of gold ore reserves; exploration by the company increased reserve by 27% during 1989 to a total of 640 metric tons (20.7 million ounces) contained in 10 deposits located along a northwest-trending geological structure frequently referred to as the Carlin trend. During the year, NGC produced a record 45,648 kg (1.47 million ounces) of gold from ore mined at six open pits in Eureka and Elko Counties. Newmont also operated five separate mills and four leaching facilities in the same counties. The company's Gold Quarry Mine in Eureka County produced almost as much gold during 1989 as the entire Nation produced in 1980. According to the company, total production costs, including deprecation depletion and amortization, were $273 an ounce in 1989 compared with $266 an ounce the previous year. Pursuant to a decision announced the previous year, NGC moved its corporate headquarters from New York to Denver, CO, in 1989.

American Barrick Resources Corp. planned to develop its Betze deposit sulfide reserve and its Post deposit oxide reserves at the company's Goldstrike Mine. Goldstrike, adjacent to NGC's operations on the Carlin trend in north-

ern Eureka County, was one of the leading gold-producing mines in 1989. During 1989, Goldstrike yielded more than 6,446 kg (207,264 ounces), well above its production target of 5,598 kg (180,000 ounces). In June, Goldstrike received the first of six 1,500-ton-per-day autoclaves to be installed to convert the mine's gold-bearing sulfide ores to oxides for subsequent cyanide treatment and gold recovery. Construction and commissioning of the new autoclave was completed near yearend. Exploration by Barrick in the Goldstrike area encountered three new areas of gold mineralization.

Nevada's second largest gold mine and the fourth largest in the Nation, the Jerritt Canyon Mine of Freeport McMoRan and FMC in Elko County, reported gold production of 9,234 kg (296,900 ounces) during 1989 at a production cost of $166 per ounce. Freeport also holds a majority interest in the nearby Big Springs Mine where 1,882 kg (60,500 ounces) was produced. During the year expansion programs begun the previous year at both mines were completed. New and proprietary ore-roasting facilities became operational in June at Big Springs and in September at Jerritt Canyon. The roasting facilities increased the mines' ore reserve base and production capacities by allowing the milling of previously unacceptable ore.

In Lander County, expansion work on Echo Bay's McCoy-Cove gold and silver mine moved ahead with completion of a new mill in July and the driving of two access ramps, one to 183 meters (600 feet) below the surface at the Cove deposit and another 274 meters (900 feet) below McCoy. Underground mining at Cove began in December. Gold production from both surface and underground workings at McCoy-Cove more than doubled during 1989 to 6,673 kg (214,566 ounces). Underground problems related to poor ground conditions and substantial waterflows at Cove forced the company to modify its planned underground mining rate. A problem related to contaminated samples derived by reverse-circulation drilling below the water table resulted in a substantial negative revision of Cove's ore reserves.

At the nearby Lander County operations of Battle Mountain Gold Co., more than 7,800 kg (251,000 ounces) of gold was recovered during the year from the company's Canyon Placer Mine and two open pit lode mines, the Fortitude and the Surprise.

The world's largest heap-leach gold mine, the Round Mountain Mine in Nye County, completed a 2 year expansion program in 1989 that effectively doubled its tonnage capacity. Published company data reported gold production during the year at 9,909 kg (318,616 ounces). In January, the mine's owners, Homestake, Echo Bay, and Case Pomeroy & Co., merged Echo Bay's nearby properties, including the Manhattan mill, into the Round Mountain operations, thereby enabling the mine to achieve better recovery rates on its high-grade ore than could otherwise be achieved by heap leaching.

Just west of the town of Beatty in Southern Nye County, Bond Gold Bullfrog Inc. poured its first gold in July at the newly commissioned Bullfrog Mine and mill. Bullfrog was expected to produce more than 6,344 kg (204,000 ounces) in its first full-year of production. Several kilometers to the east the U.S. Nevada Gold Search Joint Venture began production near yearend at its new open pit, heap-leaching Mother Lode Mine.

The mines previously mentioned were only a small portion of the scores of gold properties in Nevada that were in operation during 1989, undergoing design, construction or permitting, expanding production capacity, or in various stages of exploration from claim staking to reserve evaluation.

Oregon

A State-prepared review of mining in Oregon during 1989 listed 10 active gold mines; 2 seasonal lode mines, the Pyx and the Lower Grandview; and 8 placer mines.[7] Of the 34 active exploration sites and areas in Oregon during the year, only 4 sought commodities additional to gold.

Oregon's total gold production for the year was attributable mostly to the Bonanza Mining Co.'s 46 cubic meter per day (60 cubic yd per day) placer operation on Pine Creek in Baker County. The State reference noted that although stripping and mining progressed in one area of the pit, backfilling and site reclamation was proceeding in another part.

The rush precipitated by the 1988 discovery of the large Grassy Mountain deposit in Malheur County by Atlas Precious Metals Co. accelerated during 1989. Near yearend, close to 8,000 new claims had been located mostly in northern Malheur County, thus bringing the county total to more than 21,000. Exploration drilling was done on at least 16 properties. In the meantime, at Grassy Mountain, Atlas continued drilling while preparing feasibility studies and collecting supporting environmental and water-quality data. An operating plan calling for the development of two open pits and a heap-leach recovery system was submitted to the U.S. Bureau of Land Management in November.

Also in northern Malheur County, Chevron Resources Co. continued exploration of three different areas, including their Hope Butte and Quartz Mountain properties.

In Lake County, south-central Oregon, Quartz Mountain Gold Corp. formed a joint venture with Pegasus Gold to further explore and develop a mine plan for two large gold deposits discovered in 1986.

South Carolina

Near the town of Ridgeway in Fairfield County, the Ridgeway Mine of Ridgeway Mining Co. completed its first full-year of operation. The first year's performance at the new mine, a joint venture between Galactic Resources Ltd. and the RTZ Corp. PLC, was consistently in excess of expectations, producing 5,365 kg (172,505 ounces) of gold compared with a budgeted production of 4,978 kg (160,064 ounces). According to Galactic Resources, the average production cost during 1989 amounted to $140 per ounce, significantly lower than the $167 per ounce expected earlier. The lower cost reportedly reflected high mill throughput, enhanced recoveries, and low reagent consumption.

Despite lower gold prices and production delays attributed to bad weather, Piedmont Mining Co.'s Haile Mine near Kershaw in Lancaster County produced an increased amount of gold compared with the previous year. Gold production at the open pit, heap-leaching operation was 481 kg (15,458 ounces) in 1989 compared with 365 kg (11,738 ounces) in 1988. Surface mining and heap leaching was continued at the Brewer Mine just west of Jefferson in Chesterfield County. The mine, opened in 1987, is owned by Westmont Mining Inc.

In McCormick County, Gwalia (U.S.A.) Ltd., a wholly owned subsidiary of Gwalia International Ltd. of

Perth, Western Australia, conducted exploration and drilling aimed at reopening the old gold mines around the town of McCormick. The old mines, including the old Dorn Mine, produced gold between the 1850's and 1930's. Gwalia's operation was referred to as the Barite Hill Project.

South Dakota

Gold was produced by five primary gold mines, including the Homestake Mine, the Nation's third largest. All five mines were located in Lawrence County.

The 114-year-old Homestake Mine's production in 1989 was 11,874 kg (381,788 ounces), down slightly from the 1988 record level of 12,134 kg (390,162 ounces). Homestake operated both surface and underground mines at the town of Lead. The surface operation, referred to as the Open Cut, was begun in 1985, on the site of the original 1876 gold strike. During the year Homestake processed about 2.3 million metric tons of ore from both the surface and underground operations. The grade of underground ore declined about 4% to 6.17 grams per metric ton (0.180 ounce per short ton) and, this, combined with slightly higher labor costs, caused production costs to increase slightly to $301 per ounce. During the year Homestake completed construction of a new plant to process tailings dam water for an expected annual recovery of an additional 218 kg (7,000 ounces) of gold. Exploration, mostly below the 2,073 meter (6,800 foot) level, added about 28,000 kg (0.8 million ounces) of gold to the mine's reserves.

Bond Gold-Richmond Hill Inc. began production in early 1989 at its Richmond Hill Mine located 8 km (5 miles) northwest of Lead. The new open pit, heap-leaching mine was expected to produce about 1,244 kg (40,000 ounces) of gold annually. Wharf Resources (USA) Inc. continued production at its Annie Creek open pit, heap-leaching operation near Terry Peak. A new treatment plant completed in late 1988 was expected to increase Wharf's 1989 production by about 30% over the previous year's level of 1,850 kg (59,500 ounces). Golden Reward Mining Co. began production at its new open pit and heap-leaching Golden Reward Mine in November. The first gold bar was poured in mid-December.

MinVen Gold Corp. completed its first full year at its Gilt Edge Mine located 6.4 km (4 miles) south of Lead. In early 1989, the company submitted a plan to the U.S. Forest Service that, if approved, could quadruple the size of the new open pit, heap-leaching facility. The expansion was aimed at utilizing the mine's sulfide ore deposits adjacent to, and deeper than, the oxide ore presently being mined.

An environmental group based in Rapid City filed a petition in November to place an acreage limit on Black Hills surface mining. The group wants an initiative on the November 1990 general election ballot that would limit to 1,255 hectares (3,100 acres) the amount of land that could be mined at any one time by large-scale precious metals mining companies in the Black Hills.

Utah

The year witnessed the first full-year of copper and byproduct gold production at the giant Bingham Canyon Mine near Salt Lake City since completion of a $400 million modernization program begun several years earlier. Bingham Canyon, owned by RTZ and operated by the Kennecott Corp., was the Nation's second largest producer in 1989 of both copper and byproduct gold. The mine was the State's largest producer of both gold and silver. In the fall of the year, Kennecott began

TABLE 3

TWENTY-FIVE LEADING GOLD-PRODUCING MINES IN THE UNITED STATES IN 1989, IN ORDER OF OUTPUT

Rank	Mine	County and State	Operator	Source of gold
1	Carlin Mines Complex	Eureka, NV	Newmont Gold Co.	Gold ore.
2	Bingham Canyon	Salt Lake, UT	Kennecott-Utah Copper Corp.	Copper ore.
3	Homestake	Lawrence, SD	Homestake Mining Co.	Gold ore.
4	Jerritt Canyon (Enfield Bell)	Elko, NV	Freeport-McMoRan Gold Co.	Do.
5	Smoky Valley Common Operation	Nye, NV	Round Mountain Gold Corp.	Do.
6	Mesquite	Imperial, CA	Goldfields Mining Co.	Do.
7	McLaughlin	Napa, CA	Homestake Mining Co.	Do.
8	Sleeper	Humboldt, NV	Amax Gold Inc.	Do.
9	Fortitude and Surprise	Lander, NV	Battle Mountain Gold Co.	Do.
10	Chimney Creek	Humboldt, NV	Gold Fields Mining Co.	Do.
11	Ridgeway	Fairfield, SC	Ridgeway Mining Co.	Do.
12	McCoy and Cove	Lander, NV	Echo Bay Mining Co.	Do.
13	Paradise Peak	Nye, NV	FMC Gold Co.	Do.
14	Goldstrike	Eureka, NV	Barrick Goldstrike Mines Inc.	Do.
15	Cannon	Chelan, WA	Asamera Minerals (U.S.) Inc.	Do.
16	Getchell	Humboldt, NV	FMG Inc.	Do.
17	Mercur	Tooele, UT	Barrick Mercur Gold Mines Inc.	Do.
18	Golden Sunlight	Jefferson, MT	Golden Sunlight Mines Inc.	Do.
19	Jamestown	Tuolumne, CA	Sonora Mining Corp.	Do.
20	Zortman-Landusky	Phillips, MT	Pegasus Gold Inc.	Do.
21	Borealis	Mineral, NV	Echo Bay Mining Co.	Do.
22	Crofoot and Lewis	Humboldt, NV	Hycroft Resources & Development Inc.	Do.
23	Florida Canyon	Pershing, NV	Florida Canyon Mining Inc.	Do.
24	Rochester	do.	Coeur Rochester Inc.	Do.
25	Robinson Project	White Pine, NV	Alta Gold Co.	Do.

TABLE 4

GOLD PRODUCED IN THE UNITED STATES, BY STATE, TYPE OF MINE, AND CLASS OF ORE

Year and State	Placer (kilograms of gold)	Lode					
		Gold ore		Gold-silver ore		Silver ore	
		Metric tons	Kilograms of gold	Metric tons	Kilograms of gold	Metric tons	Kilograms of gold
1985	2,280	32,576,032	67,523	946,969	1,300	3,480,080	973
1986	2,281	55,050,375	110,217	788,434	883	5,019,289	691
1987	5,082	84,195,951	137,832	W	W	7,944,696	1,235
1988	4,754	127,883,933	r181,191	W	W	9,573,505	2,075
1989:							
Alaska	W	W	W	—	—	—	—
Arizona	W	744,746	1,390	—	—	—	—
California	W	W	W	—	—	—	—
Colorado	22	W	W	—	—	—	—
Idaho	W	W	W	W	W	W	W
Michigan	—	W	W	—	—	—	—
Montana	(1)	14,857,997	9,720	—	—	W	W
Nevada	W	112,136,682	153,506	32,173	249	W	W
New Mexico	—	W	W	—	—	—	—
Oregon	W	23	(1)	—	—	—	—
South Carolina	—	W	W	—	—	—	—
South Dakota	—	6,183,359	16,048	—	—	—	—
Utah	—	4,440,675	5,129	W	W	292,175	21
Washington	—	W	W	—	—	—	—
Total	5,711	170,287,482	237,032	W	W	4,450,703	505
Percent of total gold	2	XX	89	XX	W	XX	(2)

	Lode				Total	
	Copper ore		Other[2]			
	Metric tons	Kilograms of gold	Metric tons	Kilograms of gold	Metric tons	Kilograms of gold[3]
1985	135,592,281	2,321	4,061,181	1,098	176,656,541	75,495
1986	105,936,857	1,643	303,845	582	167,098,800	116,297
1987	165,407,018	8,074	W	W	258,668,990	153,870
1988	r201,893,222	11,314	W	W	r340,614,832	200,914
1989:						
Alaska	—	—	W	W	451,462	5,756
Arizona	141,807,608	1,398	W	W	142,635,932	2,810
California	—	—	W	W	20,061,024	29,804
Colorado	—	—	W	W	1,554,215	3,448
Idaho	2,434,125	11	W	W	3,975,754	3,057
Michigan	—	—	—	—	W	W
Montana	W	W	W	W	20,999,774	11,623
Nevada	W	W	W	W	115,829,846	154,573
New Mexico	W	W	—	—	29,418,752	1,076
Oregon	—	—	—	—	W	W
South Carolina	—	—	—	—	W	W
South Dakota	—	—	92	75	6,183,451	16,123
Utah	W	W	—	—	W	W
Washington	—	—	—	—	W	W
Total	210,474,747	17,662	W	W	389,237,866	265,541
Percent of total gold	XX	7	XX	W	XX	100

r Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
1 Less than 1/2 unit
2 Includes lead, zinc, copper-lead, lead-zinc, copper-zinc, copper-lead-zinc ores, and old tailings, etc.
3 Includes lode and placer production.

TABLE 5

LODE GOLD PRODUCED IN THE UNITED STATES, BY STATE

Year and State	Amalgamation		Cyanidation		Smelting of concentrates			Smelting of ore		Total gold recovered (kilograms)	Total ore processed[1] (metric tons)
	Ore treated (metric tons)	Gold recovered (kilograms)	Ore treated (metric tons)	Gold recovered (kilograms)	Ore concentrated (metric tons)	Concentrates smelted (metric tons)	Gold recovered (kilograms)	Ore smelted (metric tons)	Gold recovered (kilograms)		
1985	18,880	116	35,926,506	64,970	140,510,381	2,921,563	7,207	200,774	[2]1,063	176,656,541	[2]73,356
1986	771,321	1,048	58,664,524	104,422	107,528,173	2,575,228	[2]8,171	134,782	[2]201	167,098,800	[2]113,842
1987	W	W	88,876,729	129,812	r169,472,280	3,430,726	17,548	W	W	r258,668,990	[2]148,788
1988	W	W	r133,047,109	173,493	r207,228,838	3,969,256	21,057	W	W	r340,614,832	[2]196,161
1989:											
Alaska	—	—	W	W	W	W	W	—	—	451,462	[2]5,756
Arizona	—	—	W	W	W	W	W	W	W	142,635,932	[2]2,810
California	W	W	17,878,351	25,355	W	W	W	—	—	20,061,024	W
Colorado	112,036	510	W	W	W	W	W	W	W	1,554,215	3,425
Idaho	—	—	3,071,381	W	904,373	42,467	W	—	—	3,975,754	W
Michigan	—	—	W	W	—	—	—	—	—	W	W
Montana	—	—	14,888,203	9,527	W	W	W	W	W	20,999,774	11,623
Nevada	—	—	115,524,774	152,742	W	W	W	W	W	115,829,846	W
New Mexico	—	—	—	—	W	W	W	W	W	29,418,752	1,076
Oregon	—	—	23	[3]	—	—	—	—	—	23	[3]
South Carolina	—	—	W	W	—	—	—	—	—	W	W
South Dakota	—	—	6,183,359	16,048	—	—	—	92	75	6,183,451	16,123
Utah	—	—	4,732,850	5,150	W	W	W	W	W	W	W
Washington	—	—	W	W	W	W	W	—	—	W	W
Total	W	W	170,473,179	227,229	218,468,731	4,193,848	30,325	W	W	389,237,866	263,977

r Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."
[1] Includes old tailings and some nongold-bearing ores not separable, in amounts ranging from 0.15% to 0.25% of the totals for the year listed.
[2] Includes some placer production to avoid disclosing company proprietary data.
[3] Less than 1/2 unit.

gold production at its new Barney's Canyon Mine located 6.4 km (4 miles) north of Bingham Canyon. The new open pit and heap-leaching mine was designed to produce approximately 2,500 kg (80,000 ounces) of gold per year.

Utah's second largest gold mine and the State's largest producer of primary gold, Barrick's Mercur Mine in Toole County, continued to operate at full capacity, producing 3,656 kg (117,536 ounces) of gold during 1989. A new autoclave unit for processing sulfide ore completed its first full-year of operation. Throughput exceeded design capacity of 680 metric tons per day, and the unit reportedly achieved an average recovery rate of 81.4% for the year. Barrick reported that a major increase in gold production resulted from improvements at the mine's dump-leaching facilities and that a third such facility was under construction at yearend.

Tenneco Minerals Inc., officially began operations in May at its new Goldstrike Mine near St. George in Washington County. The new open pit and heap-leaching operation has the capacity to produce 1,244 kg (40,000 ounces) each of gold and silver per year.

TABLE 6

GOLD PRODUCED IN THE UNITED STATES BY CYANIDATION[1]

Year	Extraction in vats, tanks, and closed containers[2]		Leaching in open heaps or dumps[3]	
	Ore treated (metric tons)	Gold recovered[4] (kilograms)	Ore treated (metric tons)	Gold recovered (kilograms)
1985	18,636,045	48,392	17,290,462	16,578
1986	24,590,938	73,362	34,073,586	31,060
1987	29,408,635	74,807	59,468,094	55,005
1988	r30,784,205	100,817	102,262,904	72,676
1989	40,642,933	121,716	129,830,246	105,513

r Revised.
[1] May include small quantities recovered by leaching with thiourea, by bioextraction and by proprietary processes.
[2] Including autoclaves.
[3] May include tailings and waste ore dumps.
[4] May include small quantities recovered by gravity methods.

Washington

According to a review of Washington State's Mineral Industry prepared by the State, Washington's largest gold mine, the Cannon Mine at Wenatchee in Chelan County, produced an estimated 4,454 kg (143,200 ounces) of gold and about 9,330 kg (300,000 ounces) of silver during 1989.[8] Comparable data for 1988 was about 4,510 kg (145,000 ounces) of gold and about 7,775 kg (250,000 ounces) of silver. The mine, a joint venture between Asamera Minerals (U.S.) Inc., the operator, and Breakwater Resources Ltd., is the Nation's second largest underground gold mine. Underground exploration to locate additional reserves was continued by Asamera, especially in the northern and western extensions of the B–4 ore zone, in the B-west ore body, and in the B-north zone. Surface exploration was also conducted in the Wenatchee Heights area 5.6 km (3.5 miles) southeast of the mine.

Washington's second largest gold mine is the underground Republic Unit, or Knob Hill Mine, of Hecla in Republic, Ferry County. On May 26 the 2 millionth ounce (62.2 metric tons) of gold was hoisted from the Knob Hill No. 2 shaft. This 541-meter (1,774 foot) inclined shaft has made over 4 million trips since it was opened in 1940. During 1989, the Republic Unit recovered 2,312 kg (74,335 ounces) of gold and 9,375 kg (301,432 ounces) of silver. Hecla also completed modifications to the mine's 52-year-old concentrator during 1989, raising its capacity from 218 metric tons per day to 245 metric tons per day. Improved gold recovery circuits were also installed during the overhaul.

Development was continued at Echo Bay and Crown Resources Corp.'s Kettle River project. The project located in Ferry County, 18 km (11 miles) north of Republic, includes the new Kettle and Overlook underground mines. Construction of a new 1,260 metric-ton-per-day automated flotation mill, employing carbon-in-pulp and vat-leaching systems, was completed before yearend. Commercial production was begun in February 1990.

The State reported that more than 80 companies and individuals explored for metals in Washington during 1989. Gold, particularly gold in Skarn and replacement deposits and epithermal gold-bearing deposits in Eocene-age rock in

TABLE 7

GOLD PRODUCED AT PLACER MINES IN THE UNITED STATES, BY METHOD OF RECOVERY[1]

Method of recovery	Mines producing	Washing plants	Material washed (thousand cubic meters)	Gold recoverable		
				Quantity (kilograms)	Value (thousands)	Average value per cubic meter
Bucketline dredging:						
1985	3	4	3,026	997	$10,185	$3.366
1986	3	4	3,120	948	11,227	3.598
1987	4	5	7,136	3,471	49,989	7.006
1988	3	4	5,775	2,590	36,497	6.320
1989	3	4	5,560	2,720	33,454	6.016
Dragline dredging:						
1985	3	14	[2]119	[3]132	1,348	[4]2.908
1986	3	14	[2]11	[3]113	1,342	[4]16.823
1987	3	3	[2]71	[3]67	971	[4]8.190
1988	—	—	—	—	—	—
1989	—	—	—	—	—	—
Hydraulicking:						
1985	—	—	—	—	—	—
1986	1	1	76	1	17	0.217
1987	—	—	—	—	—	—
1988	—	—	—	—	—	—
1989	—	—	—	—	—	—
Nonfloating washing plants:						
1985	6	6	733	949	9,690	13.213
1986	4	4	211	781	9,244	43.852
1987	6	6	636	465	6,698	10.526
1988	6	6	473	302	4,255	9.004
1989	4	4	72	92	1,134	15.851
Underground placer, small-scale mechanical and hand methods, suction dredge:						
1985	19	19	474	202	2,061	4.343
1986	24	24	679	438	r5,180	7.631
1987	15	15	367	1,078	r15,529	42.330
1988	13	13	[2]838	[3]1,862	r26,225	[4]31.292
1989	20	20	[2]1,404	[3]2,899	35,654	[4]25.349
Total placers:[5]						
1985	31	43	[2]4,353	[3]2,280	23,284	[4]5.118
1986	35	47	[2]4,097	[3]2,281	r27,010	[4]6.309
1987	28	29	[2]8,210	[3]5,082	r73,187	[4]8.867
1988	22	23	[2]7,085	[3]4,754	r66,977	[4]9.453
1989	27	28	[2]7,036	[3]5,711	70,242	[4]9.975

r Revised.

[1] Data are only for those mines that report annually on the Bureau of Mines voluntary survey; there are many more, usually smaller and less well-established operations, mainly in Alaska, that do not report.

[2] Excludes tonnage of material treated at commercial sand and gravel operations recovering byproduct gold.

[3] Includes gold recovered at commercial sand and gravel operations.

[4] Gold recovered as a byproduct at sand and gravel operations not used in calculating average value per cubic meter.

[5] Data may not add to totals shown because of independent rounding.

northeastern Washington, was the principal target of this exploration.

CONSUMPTION AND USES

The use of gold in the domestic market shown in table 9 accounts for only part of the overall market for commercial products. An important segment of market demand is also satisfied by imported gold-bearing products in various forms ranging from unfinished, jewelry products, such as gold chain and findings, to electronic equipment containing gold components.

Contracts for gold futures traded during 1989 on the Nation's futures exchanges represented about 31,330 metric tons (1,007 million ounces) compared with the previous year when the equivalent of nearly 30,000 metric tons (962 million ounces) were traded. The New York-based Commodity Exchange Inc. (COMEX) was, as in the previous year, by far the dominant exchange with an equivalent of more than 31,000 metric tons (999 million ounces) of gold traded during 1989.

Sales of newly-minted gold coins by the U.S. Mint declined somewhat from levels establish during previous years. The sales program for the Bicentennial of the U.S. Congress Commemorative coins began in June, and the sales program for the 1988 Olympic coins, begun in February 1988, was completed in June 1989. During the fiscal year ending on Sept 30, 1989 about 2,140 kg (68,800 ounces) of gold was used to satisfy various official minting programs.

Gold loan activity between commercial depository banks and gold producers continued to be a popular method of financing new mine development or expansion of existing facilities.

In addition to its age-old usage in jewelry, decorative applications, and dentistry, gold has a number of applications that are important to the functioning of domestic industry, modern high technology, engineering, and defense systems. It is used extensively in a great variety of solid-state electronic devices, in industrial control and monitoring instruments, and in corrosion-resistant chemical process equipment.

Of the strategic and industrial uses of gold, the most important is its use in electronic devices, especially in printed circuit boards, connectors, keyboard contacts, miniaturized circuitry, and as a dopant in some semiconductors. Modern solid-state electronic devices such as computers employ very low voltages and currents, and thus require connectors, switch contacts, soldered joints, and certain other components that must remain completely free of high resistance tarnish films and that remain chemically and metallurgically stable for the life of the device. Increasingly complex civilian, military, and aerospace electronic systems use gold to ensure dependable operations under a wide range of operating conditions. For example, because of its ability to provide reliable electrical connections, gold is used extensively in all spacecraft such as the *Hubble Space Telescope* that must function flawlessly over a long period of time in the harsh environment of outer space.

Gold alloys have long been used in certain electrical instruments, for example, as wipers and windings in slide-wire potentiometers, where long-term reproducibility is essential. Gold-palladium alloy wires are used in thermocouples, especially those used to measure high temperatures encountered in some industrial processes and aircraft engines. Gold-containing brazing alloys such as gold-nickel alloy are important to the aerospace industry, especially in the as-

TABLE 8

U.S. REFINERY PRODUCTION OF GOLD[1]

(Kilograms)

Raw material	1985	1986	1987	1988	1989
Concentrates and ores:					
Domestic and foreign	64,583	75,618	112,368	137,829	183,685
Old scrap	49,824	47,266	63,843	52,807	36,895
New scrap	46,964	50,785	39,723	75,150	120,554
Total[2]	161,370	173,668	215,933	265,786	341,135

[1] Data may include estimates.
[2] Data may not add to total shown because of independent rounding.

TABLE 9

U.S. CONSUMPTION OF GOLD,[1] BY END USE SECTOR[2]

(Kilograms)

End use	1985	1986	1987	1988	1989
Jewelry and the arts:					
Karat gold	43,473	43,916	49,304	r48,037	49,120
Fine gold for electroplating	762	2,689	3,133	1,469	1,127
Gold-filled and other	6,716	6,780	6,706	4,581	4,106
Total[3]	50,951	53,385	59,142	r54,088	54,353
Dental	9,309	7,921	6,944	7,576	7,923
Industrial:					
Karat gold	1,216	1,202	1,176	233	252
Fine gold for electroplating	11,864	11,486	12,250	14,988	20,575
Gold-filled and other	22,748	23,050	20,948	20,950	15,632
Total[3]	35,828	35,738	34,374	36,172	36,459
Small items for investment[4]	231	189	106	7	7
Grand total[3]	96,318	97,234	100,566	r97,842	98,741

r Revised.
[1] Gold consumed in fabricated products only; does not include monetary bullion.
[2] Data may include estimates.
[3] Data may not add to totals shown because of independent rounding.
[4] Fabricated bars, medallions, coins, etc.

sembly of some military jet turbine engines and high- performance rocket engines. Gold is used as a reflector of infrared radiation in radiant heating and drying devices and heat-insulating windows for large buildings and spacecraft such as the *space shuttle*, which relies upon gold to seal and protect its vital propulsion system from problems associated with hydrogen embrittlement. Gold-coated mirrors are the principal component of infrared jammers used on numerous military aircraft to confuse the guidance instruments of heat-seeking missiles.

Gold, applied as organometallic liquids, is used for the decoration of porcelain and glass dinnerware; gold leaf is used for the decoration of buildings, both inside and outside; and gold alloys are used in rupture discs in chemical process eqiupment and in the perforated "spinnerets" through which cellulose acetate fibers are extruded. Since 1975, a small amount of gold has been used in the United States each year for medallions, small bars, and other similar items having high gold content, purchased primarily as investments.

STOCKS

Stocks of refined bullion held by industrial users at the end of the year were substantially lower than those held at the end of 1988. The sharpest declines in industrial stocks were reported during the first and second quarters of the year and may reflect a withdrawal of material by manufacturers to meet the continuing demand, especially for jewelry products destined for sale later in the year.

Yearend stocks of gold certified for delivery by COMEX, the Nation's largest futures exchange, increased substantially from those held at the end of the previous year.

PRICES

The Engelhard Industries-London daily final price of gold ranged from a low of $357 per ounce in September to a year's high of nearly $417 per ounce in mid-December. Despite the strong surge in the price toward yearend, the average for the year amounted to about $383 per ounce or nearly $60 per ounce less than the average for 1988.

TABLE 10

YEAREND STOCKS OF REFINED GOLD IN THE UNITED STATES

(Kilograms)

	1985	1986[r]	1987[r]	1988[r]	1989
Industry	18,538	28,771	23,390	38,360	24,828
Futures exchange[1]	65,628	87,370	81,647	44,634	69,727
Department of the Treasury[2]	8,170,019	8,149,938	8,160,251	8,144,782	8,146,255
Earmarked gold[3]	10,494,290	10,348,006	10,252,982	10,044,519	9,911,928

[r] Revised.
[1] Commodity Exchange Inc. only. Stocks held by other exchanges estimated to be less than 2% of totals shown.
[2] Includes gold in Exchange Stabilization Fund.
[3] Gold held for foreign and international official accounts at New York Federal Reserve Bank.

TABLE 11

U.S. GOLD PRICES[1]

(Dollars per troy ounce)

Period	Low		High		Average
	Price	Date	Price	Date	
1985	284.64	Feb. 25	341.30	Aug. 19 and 28	317.66
1986	326.70	Jan. 2	438.50	Oct. 8	368.24
1987	391.51	Feb. 18	501.25	Dec. 14	447.95
1988	396.62	Sept. 26	485.37	Jan. 8 and 11	438.31
1989:					
January	395.32	Jan. 30 and 31	412.95	Jan. 3	405.35
February	381.70	Feb. 17	395.12	Feb. 9	389.08
March	384.25	Mar. 29	396.82	Mar. 20	391.46
Apsil	378.84	Apr. 28	391.56	Apr. 13	385.70
May	361.01	May 22	379.89	May 3	372.61
June	359.96	June 13	377.59	June 29	368.90
July	369.58	July 31	386.81	July 6	376.29
August	361.06	Aug. 29 and 31	371.78	Aug. 4	366.19
September	357.00	Sept. 15	370.28	Sept. 27	363.16
October	362.31	Oct. 11	376.59	Oct. 31	368.16
November	374.33	Nov. 1	415.10	Nov. 27	393.64
December	399.93	Dec. 28	416.86	Dec. 11 and 12	410.44
Year	357.00	Sept. 15	416.86	Dec. 11 and 12	382.58

[1] Engelhard Industries daily quotation.

FOREIGN TRADE

U.S. exports of gold, though not as large as in the previous year, were nevertheless substantial when compared with many earlier years. Contrary to 1987 and 1988, when Taiwan was the principal recipient of U.S. refined bullion shipments, exports to that country all but ceased during 1989. Switzerland was instead the principal destination during 1989, receiving large quantities of both refined bullion and doré.

Canada continued to be the Nation's principal source of refined bullion. Imports of gold from Uruguay which began in earnest in 1980 and peaked in 1986, declined in 1989 to roughly their 1980 level. During the 1980–89 period, Uruguay, a country with little or no domestic production and no official

controls on gold trade, became an important conduit for newly mined gold originating in other Latin American nations, especially Brazil where the trade of gold is tightly controlled. The dramatic decline in exports of gold from Uruguay in February 1989 may in part have been related to the discovery and closure there of an international money laundering operation reportedly involving the export of gold plated lead bars.

WORLD REVIEW

In 1989, for the 10th consecutive year, world gold mine production exceeded that of the previous year. Gold Fields Mineral Services Ltd.,[9] continuing the annual statistical survey prepared over the previous 23 years by its predecessor Consolidated Gold Fields PLC, noted that world demand for gold in the market economy countries (MEC) reached another new record, surpassing the previous record set in 1988.

The company began its summary by noting that in addition to the supply of

TABLE 12

U.S. EXPORTS OF GOLD, BY COUNTRY[1 2]

Year and country	Ores and concentrates[3]		Wastes and scrap		Doré and precipitates		Refined bullion		Total[4]	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
1985	76	$771	30,486	$303,413	2,979	$30,147	89,837	$919,433	123,378	$1,253,764
1986	166	1,589	30,452	352,471	14,192	158,005	110,555	1,306,958	155,365	1,819,023
1987	1,385	19,818	28,092	390,832	18,976	264,008	71,177	1,034,186	119,630	1,708,844
1988	1,384	18,449	35,709	492,840	19,809	265,051	271,335	3,882,757	328,237	4,659,098
1989:										
Belgium	—	—	1,238	15,669	—	—	1	30	1,239	15,699
Brazil	—	—	—	—	—	—	104	1,339	104	1,339
Canada	9	110	7,959	95,729	5,251	64,257	11,730	138,550	24,948	298,647
China	—	—	69	323	—	—	—	—	69	323
Costa Rica	—	—	—	—	—	—	99	1,144	99	1,144
Dominican Republic	—	—	141	1,123	—	—	31	389	172	1,512
France	—	—	16,079	200,370	994	12,362	1,451	17,839	18,525	230,571
Germany, Federal Republic of	(5)	2	2,094	24,475	1,427	17,529	84	965	3,605	42,970
Haiti	—	—	216	2,110	—	—	—	—	216	2,110
Hong Kong	—	—	499	6,514	—	—	39,656	481,999	40,155	488,512
India	—	—	30	231	1	12	26	293	58	536
Israel	—	—	24	172	39	406	—	—	62	578
Italy	—	—	181	2,260	40	480	52	600	273	3,340
Japan	—	—	5	43	136	1,445	5,472	70,864	5,613	72,352
Korea, Republic of	7	53	(5)	4	—	—	33	374	40	432
Mexico	—	—	353	3,664	149	1,881	6,652	78,338	7,154	83,883
Peru	—	—	37	547	—	—	1,123	12,827	1,160	13,374
Poland	—	—	—	—	—	—	70	787	70	787
Singapore	—	—	—	—	—	—	5,874	69,410	5,874	69,410
Sweden	—	—	880	10,537	138	1,442	—	—	1,018	11,979
Switzerland	—	—	857	9,754	34,618	141,097	31,383	378,989	66,858	529,840
United Kingdom	—	—	13,857	168,481	110	1,436	19,020	226,847	32,987	396,764
Uruguay	—	—	—	—	—	—	472	5,500	472	5,500
Yugoslavia	—	—	—	—	—	—	215	2,426	215	2,426
Other	—	—	22	143	32	344	52	640	106	1,128
Total[4]	16	165	44,541	542,150	42,935	242,690	123,599	1,490,151	211,091	2,275,156

[1] Because of the implementation of the Harmonized Tariff System in Jan. 1989, import and export data may not be comparable with previous years' data.
[2] Bullion also moves in both directions between U.S. markets and foreign stocks on deposit in the Fedal Reserve Bank. Monetary gold excluded.
[3] Includes gold content of base metal ores, concentrates, and matte destined for refining.
[4] Data may not add to totals shown because of independent rounding.
[5] Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 13

U.S. IMPORTS FOR CONSUMPTION OF GOLD, BY COUNTRY[1,2]

Year and country	Ores and concentrates[3]		Wastes and scrap		Doré and precipitates		Refined bullion		Total[4]	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
1985	1,153	$11,628	11,411	$107,147	45,444	$468,227	197,849	$2,109,475	255,857	$2,696,478
1986	1,170	13,094	16,184	159,786	43,267	504,457	429,242	5,016,558	489,863	5,693,896
1987	1,429	17,926	13,955	160,073	28,790	402,026	75,365	1,052,941	119,539	1,632,966
1988	2,621	34,141	r6,468	r79,483	25,778	355,763	r57,590	799,901	r92,457	r1,269,288
1989:										
Australia	—	—	35	305	—	—	165	2,013	200	2,318
Barbados	—	—	184	1,907	—	—	13	140	197	2,047
Belgium	1	6	—	—	—	—	576	7,085	577	7,091
Bolivia	—	—	497	3,578	—	—	1,759	22,178	2,256	25,755
Brazil	—	—	—	—	—	—	476	6,024	476	6,024
Canada	25	244	3,134	15,965	1,352	16,448	69,112	851,211	73,623	883,867
Chile	—	—	24	301	220	2,692	7,250	90,791	7,494	93,784
Costa Rica	148	396	—	—	—	—	—	—	148	396
Dominican Republic	—	—	1,288	6,575	5,167	62,176	—	—	6,455	68,751
Ecuador	1	16	41	308	—	—	164	1,937	207	2,261
Finland	—	—	—	—	26	335	91	1,153	117	1,488
France	—	—	108	1,068	—	—	1	13	109	1,081
Guyana	82	1,012	228	2,484	24	277	119	1,253	453	5,026
Haiti	—	—	240	1,950	—	—	—	—	240	1,950
Honduras	1,807	1,039	10	46	—	—	—	—	1,817	1,084
Hong Kong	—	—	40	170	1	12	22	286	64	468
Italy	—	—	47	479	—	—	69	930	116	1,410
Mexico	164	2,038	373	2,801	6,314	75,405	1,919	23,894	8,770	104,137
Netherlands	—	—	3,629	449	—	—	(5)	1	3,630	451
Panama	—	—	75	688	—	—	75	724	150	1,413
Peru	—	—	9	49	19	219	347	4,857	375	5,125
Singapore	—	—	8,630	2,615	—	—	1	6	8,630	2,621
Sweden	186	2,205	9	137	—	—	—	—	195	2,342
Switzerland	1	8	6,089	70,265	—	—	12,627	157,417	18,717	227,691
Taiwan	—	—	13,177	538	—	—	—	—	13,177	538
Trinidad	—	—	162	1,800	—	—	18	262	180	2,062
United Kingdom	—	—	1,771	404	—	—	1,192	14,894	2,962	15,298
Uruguay	—	—	—	—	—	—	662	7,986	662	7,986
Yugoslavia	—	—	—	—	—	—	151	1,885	151	1,885
Other	10	140	155	804	35	389	157	1,792	358	3,124
Total[4]	2,426	7,103	39,952	115,685	13,159	157,952	96,967	1,198,734	152,504	1,479,473

r Revised.

[1] Because of the implementation of the Harmonized Tariff System in Jan. 1989, import and export data may not be comparable with previous years' data.

[2] Bullion also moves in both directions between U.S. markets and foreign stocks on deposit in the Federal Reserve Bank. Monetary gold excluded.

[3] Includes gold content of base metal ores, concentrates, and matte destined for refining.

[4] Data may not add to totals shown because of independent rounding.

[5] Less than 1/2 unit.

Source: Bureau of the Census.

newly-mined gold and net sales to the MEC from the centrally planned economy (CPE) countries the main addition to the supply was derived from sales to the market by the world's central banks. Central banks, for the first time since 1984, were substantial net sellers of gold. Net sales by central banks amounted to 225 metric tons (7.2 million ounces), the highest since 1979. Gold releases to the market by investors in North America and especially Europe continued to be important sources of supply with much of this gold going directly to investors in Asia. Net sales of gold from the CPE Countries increased from 263 metric tons (8.5 million ounces) in 1988 to 296 metric tons

(9.5 million ounces) during 1989. Supplies of old gold scrap declined for the third consecutive year to 304 metric tons (9.8 million ounces).

Fabrication data on gold was assembled by Gold Fields from MEC data describing the trade in gold bullion and its use by industries in the MEC that transform bullion into marketable products. Gold, including gold scrap, fabricated into karat gold jewelry absorbed 1,811 metric tons (58 million ounces) or 23% more than in 1988. The company stated that the new gold component of jewelry manufacturing rose by as much as 30% because of the decline in available scrap. Jewelry fabrication grew steadily in North America and reached record levels in Europe and the Far East. Gold products fabricated for use in electronic applications rose by 3% from the previous year to 138 metric tons (4.4 million ounces) while gold used in other industrial and decorative applications grew by 6% to 62 metric tons (2.0 million ounces). The use of gold in dentistry declined slightly from the 1988 level to 49 metric tons (1.6 million ounces). Gold absorbed in the fabrication of medals and imitation coins rose fractionally to 19 metric tons (614,000 ounces). Gold minted into official coins declined 10% to 123 metric tons (3.9 million ounces); however, sales, at 127 metric tons (4.1 million ounces), were little changed from the previous year. The identified hoarding of gold bars outside of Europe and North America as measured by statistics for cross-border movement rose nearly 13% from 1988 to 516 metric tons (16.6 million ounces) in 1989.

Capacity

Rated annual production capacities for gold mines, as of December 31, 1989, are shown in table 14. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time at a normally sustainable long-term operating rate, based on the physical equipment of the plant and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure.

A telephone survey of leading domestic producers responsible for 75% of current output was conducted in late 1989. The survey indicated a current capacity utilization rate of better than 97%. Incomplete data on the utilization rate for those mines responsible for the remaining 25% of production suggested that although most are probably operating at a rate comparable with the leading producers, some, for a variety of factors, may be operating at rates low enough to reduce the overall utilization rate to about 96%, as reflected in table 14. This estimated rate was believed to reflect the level of performance in most of the other industrialized nations.

Because of to the size, diversity, and explosive growth of primary gold production over the past decade, comprehensive world capacity data that would include all operating units that contribute to national totals are generally not available. Therefore, in the absence of appropriate data, certain broad assumptions must be employed to derive international capacity numbers that are compatible with production data shown in table 15.

Optimum engineering capabilities may be more or less restrained by a combination of factors relating to Government and business attitudes, climate, location, ore grade and hardness, and mineralogy. With these and other considerations in mind, the author derived and applied to annual production data different conversion factors to approximate rated annual capacity for each producing nation.

Production data for individual nations were estimated to reflect a utilization rate from 75% of maximum capacity utilization for some essentially nonindustrialized nations up to a 96% utilization for most industrialized nations.

Reserves

Demonstrated U.S. reserves of gold were about 4,980 metric tons (about 160 million ounces), and the reserve base was 5,480 metric tons (176 million ounces). Most of the U.S. gold reserve base shown in table 14 is confined to 18 states, with about 80% of the total in Alaska, California, Idaho, Montana, Nevada, and Washington. A dominant portion of the reserve base occurs in lode deposits.

Total world reserves shown in the table approximated 42,000 metric tons (1.4 billion ounces), of which nearly one-half are in the Republic of South Africa. The world reserve base for gold totals about 47,000 metric tons (1.5 billion ounces). Reserves of gold in the U.S.S.R. and China are believed to exceed 6,220 metric tons (200 million ounces).

Estimates of reserves become available only over a period of time. The reserves shown for Australia, Brazil, Canada, and the United States, generally reflect post-1980 data and the success of exploration efforts frequently initiated years earlier in response to rising prices.

Australia

With nearly 202 metric tons (6.5 million ounces) of gold produced during 1989, Australia maintained its position as the world's fourth largest gold producing nation. The Australian gold mining industry, like its U.S. counterpart, has experienced phenomenal growth in recent years, with production rising nearly twelvefold during the period from 1980 through 1989.

The State of Western Australia continued to maintain its dominance as the nation's largest gold-producing State, hosting, during 1989, 14 of the nation's 15 leading gold mines. The State and the nation's largest gold mine, the Boddington Mine located 113 km (70 miles) southeast of Perth, continued producing at or near its recently doubled capacity rate of nearly 12,500 kg (400,000 ounces) of gold per year. Boddington is managed by the Worsley joint venture. Production at Australia's second largest mine, Newmont Australia Ltd. and BHP Gold's large open pit Telfer Mine near Nullagine was setback during 1989 by labor problems and a mid-year collapse of one wall of the open pit. These setbacks, in turn, delayed the owner's plans to initiate the first stage of a planned underground development project designed to expand the mine's annual production rate to nearly 11,000 kg (350,000 ounces) by 1991.

Some other developments in Western Australia in 1989 included the following: In October, Homestake Gold of Australia Ltd. (HGAL) poured the first gold at its new wholly owned Fortnum Mine north of Meekathara. HGAL and Gold Mines of Kalgoorlie Ltd. completed a 50–50 joint-ownership agree-

TABLE 14

WORLD GOLD ANNUAL PRODUCTION CAPACITY, RESERVES, AND RESERVE BASE,[1] DECEMBER 31, 1989

(Metric tons)

	Rated mine capacity[e]	Reserves[2]	Reserve base[3]
Australia	210	1,800	2,020
Brazil	120	930	980
Canada	165	1,700	1,870
China	95	NA	NA
Other centrally planned economies	15	NA	NA
Other market economy countries	315	6,620	7,420
South Africa, Republic of	630	20,000	22,000
United States	275	4,840	5,130
U.S.S.R.	325	6,220	7,780
World total	2,150	[4]42,000	[4]47,000

[e] Estimated. NA Not available.

[1] Estimated as of Jan. 1989. Data may not add to totals shown because of independent rounding.

[2] Reserves listed for countries other than Australia, Canada, the Republic of South Africa, and the United States may, in some instances, include inferred reserves.

[3] The reserve base includes demonstrated resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those that are currently subeconomic (subeconomic resources).

[4] Excludes China and other centrally planned economies.

ment of Kalgoorlie's famous Golden Mile. The partnership now manages the Consolidated Kalgoorlie operations, including the "Super Pit" and Mount Charlotte, the largest underground gold mine in the country, plus five mills, including the newly commissioned Fimiston Mill. The partner's offsite Gidji roaster also became operational before yearend. Other new mines beginning production during the year included Westralian Resource Projects Ltd.'s Porphyry Mine, Goldconda Minerals NL's Duketon Mine, Aztec Mining Co. Ltd's Bounty Mine, and Poseidon Ltd.'s Kaltails project. Kaltails was developed to reprocess the vast gold-bearing tailings accumulated around mines developed along Kalgoorlie's Golden Mile.

The Western Australian Mint opened its new gold refinery in Perth. The mint's companion refinery in Kalgoorlie began operations during the previous year. The two facilities have a combined annual capacity of about 10,500 kg (3.4 million ounces).

In Australia's State of Queensland, the nation's third largest individual gold mine, the Kidston, produced nearly 6,400 kg (205,361 ounces) during 1989, and in September the mine's operator, Kidston Gold Mines Ltd., celebrated the production of its millionth ounce of gold. Several of Queensland's other gold mines, including the Red Dome Mine of Elders Resources Ltd. and the Mount Leyshon Mine of Pan Australian Mining Ltd., announced plans to expand their production capacities.

Canada

Canadian gold production increased for the ninth consecutive year with most of the 1989 increase of nearly 18% attributable to gold mines in the Province of Ontario. New gold mines opened at an average of one per month during the year, thus bringing to 70 the total number of primary gold mines operating in the country. Seven mines were also closed during the year.[10]

New mines opened in Ontario during 1989 included Placer Dome's Dona Lake Mine and Flanagan McAdam Resources Inc. and Windarra Minerals Ltd.'s Magnacon Mine in the Mishibishu area of Ontario. In mid-year the Supreme Court of Canada confirmed a 1986 ruling by the Supreme Court of Ontario that the Page-Williams Mine at Hemlo belonged to Corona Corp. The ruling ended an 8-year legal battle between Corona and Lac Minerals Ltd. The Page-Williams Mine, producing nearly 15,400 kg (494,000 ounces) of gold in 1989, was the nation's largest gold producer. The old Kerr Addison Mine at Virginatown and the Surlaga Mine near Wawa were both closed owing to technical and financial difficulties.

Quebec, Canada's second largest gold-producing Province, accounted for nearly 36,000 kg (1.16 million ounces) of new Canadian gold production during the year. New Quebec gold mines becoming operational during 1989 included the Kierens Mine of Aur Resources Inc., the Beauchastel Mine near Rouyn-Noranda by Augmitto Explorations Ltd., and the nearby Pierre Beauchemin Mine and the Lucien C. Beliveau Mine near Val-d'Or, both opened by Cambior Inc. Several mines were at the final preproduction stage and at least one mine, the Bachelor Lake Mine, was closed.

Three new mines with a planned production rate in excess of 1,000 kg (32,000 ounces) per year began production in British Columbia during the year; they were the Lawyers Mine of Cheni Gold Mines Inc.; the Golden Bear Mine, an open pit, underground operation owned by Chevron Canada Resources Ltd. and Homestake; and the Premier Mine of Westmin Resources Ltd. Exploration and development was continued at a number of gold projects throughout the Province with a lot of the exploration interest focused in the Iskut River-Eskay Creek areas of Northwestern British Columbia.

Gold mining activity in the Maritime Provinces was increased with the opening in September of the new Murray Brook Mine near Bathurst, New Brunswick. Several Gold Mines in Saskatchewan and Manitoba were closed owing to depletion or financial difficulties. Production at gold mines is the Yukon and Northwest Territories increased about 4% from that of the previous year.

Latin America

Gold production in Brazil, Latin America's largest gold-producing nation, was slightly lower than that of the previous year. Factors contributing to the decline reportedly included heavy rains that affected some placer mining areas, increased regulation, higher costs, and declining grades.

In early 1989, the president of Brazil signed a decree prohibiting the use of mercury and cyanide in gold mining unless approved by Brazilian State environmental agencies. The mercury amalgamation process to collect gold concentrated during placer mining operations has

been used for many years by unregulated independent gold miners or "garimpeiros." The States most affected by mercury contamination have been those in the Pantanal and Amazon regions of Brazil.

According to Gold Field's annual review[11] production increased in the unregulated mining areas or garimpos of Roraima and Rondonia along the Western frontier near Venezuela. Production decreased in the major garimpos of Alta Floresta and Tapajós to the east, where mining was slowed by heavy rains. Although production at the Serra Pelada Mine declined sharply from the peak production year of 1983, news of a new gold discovery there reportedly caused some garimpeiros who thought the mine was depleted to flood back into the region. The new discovery, in the main street of the minesite boomtown spawned by the original mine, reportedly developed quickly into a pit large enough to threaten the foundations of nearby homes and stores. Police action was required to halt mining until an orderly development plan could be found.

Production by the formal or regulated gold mining sector rose only slightly during the year. The dominant producer, Minerçâo Morro Velho S.A., maintains interests in gold mines in the Brazilian States of Bahía and Minas Gerais as well as Goiás where, in 1989, the company began production at its new 50%-owned Crixas Mine. Some other large gold mining concerns in Brazil include Sao Bento Mineraçáo S.A., Cia Vale do Rio Doce, and Rio Paracatú Mineraçáo S.A.

Chile's favorable geological potential as well as its increasingly attractive investment climate has encouraged a large number of companies in recent years to explore for gold as well as other commodities such as copper, silver, and zinc. With an estimated 7,000 kg (225,000 ounces) of gold production in 1989, Compañía Minera El Indio was Chile's largest producer. The company produces gold from its EL Indio and nearby Tambo mines in the Fourth Region. Other large mines owned and operated by foreign and/or domestic firms include the Choquelimpie, El Bronce, and El Hueso Mines. About 30% of Chile's gold production was derived as a byproduct of base metal mining while the remainder was attributed to numerous small lode and placer mines.

In early 1989, Placer Dome and Consolidated TVX Mining Corp. opened their new La Coipa Mine in the Third Region of northern Chile. The mine was expected to produce about 6,220 kg (200,000 ounces) of gold per year by late 1991. Minera Anglo-American Chile also opened its Marte Mine in the Third Region during 1989 and planned to open its nearby Lobo project by 1992. Because of the high number of exploration and mine development projects now under way, Chile's gold production was expected to rise substantially over the next several years.

In some other large gold-producing nations of Latin America such as Bolivia, Colombia, Ecuador, and Peru, the climate for investment in mining may not be as favorable as that in Chile. As a result, much of the gold production may be attributed to the informal sector; that is, as in Brazil, to more or less unregulated miners working individually or in cooperative groups. Exploration for gold and the development of new mines in these areas was also actively pursued by the respective Governments and/or foreign and domestic firms.

Oceania

The high level of activity in gold mining and the development of new mines in many nations of the southwestern Pacific was sustained for another year. For exploration companies, the principal targets continued to be high tonnage, low-grade empithermal gold deposits similar to many recently discovered and/or developed deposits in various Western Pacific nations such as Fiji, Indonesia, Japan, New Zealand, Papua New Guinea, the Philippines, and elsewhere.

Gold production in Papua New Guinea declined about 8% from the previous year's level, reflecting in part the suspesion of operations at CRA's 53.6%-held Bougainville copper-gold mine. The Bougainville Mine, on Bougainville Island, was closed on May 15 because of continuing violence stemming from a political movement aimed at gaining the island's independence from Papua New Guinea. As a result of the closure, byproduct gold production from the mine declined to about 7,340 kg (236,000 ounces) from the nearly 14,400 kg (462,400 ounces) produced in the previous year.

In March, Placer Pacific Ltd. opened its new Misima Island gold and silver mine in Milne Bay, thus, to some extent, offsetting the loss in production from the closure of Bougainville. The first gold from the new 12,440-kg-per-year (400,000 ounces) operation was poured in May. To the west, in the highlands of Enga Province, Placer and its three partners moved toward a planned September, 1990 startup of the new Porgera Mine. At Mount Fubilan, about 200 km (124 miles) further west of Porgera, the OK Tedi copper-gold mine, the nation's largest gold mine, reportedly produced about 15,900 kg (495,00 ounces) of gold compared with the previous year's output of about 18,000 kg (581,000 ounces). The decline in 1989 production apparently reflected a combination of both labor and operational problems, plus the expected gradual depletion of the gold-enriched "cap" overlying the principal lower-grade copper-gold ore body.

Other gold-producing mines in the nation included New Guinea Goldfields Ltd.'s nearly depleted deposit at Wau and Niugini Mining Ltd.'s small Mount Victor Mine. A number of promising deposits continued to be evaluated in Papua New Guinea; Niugini Mining and RTZ prepared a final feasibility study of their extensive Lihir Island deposit; CRA was developing its Hidden Valley and Mount Kare deposits.

To the west in Indonesia's Province of West Irian, Freeport Indonesia Inc. continued copper-gold mining at its Ertsberg property while simultaneously moving toward an early 1990 startup of mining at the new Grasberg copper-gold deposit. Ertsberg is Indonesia's largest gold producing mine. In the island provinces to the west, the pace of gold exploration and development moderated somewhat from the previous year's level of activity. In January, the P.T. Ampalit Mas Perdana Mine began production in Central Kalimantan. Several major gold projects under construction or final evaluation included Royal Dutch Shell's Billiton Group's Lerokis Mine under construction on Wetar Island in Maluku Province; CRA's Kelian Gold Project Team moved at yearend to gain Government approval to begin development of its Kelian Project in East Kalimatan.

The recently reopened Martha Hill

Mine at Waihi, New Zealand, was the only lode mine operating in that country during 1989. The startup of several developing mines was delayed until operational or environmental issues could be resolved.

Gold production at the two principal mines in Fiji increased over the previous year because of the mining of higher grade ore at the Emperor Mine and improved efficiency at the newly opened Tavua Basin Mine.

South Africa, Republic of

Despite escalating production costs and steadily declining ore grades, the Republic of South Africa's gold mines continued to dominate the world gold mining scene, collectively producing more than 30% of total world production during 1989.

Most of the 603 metric tons (19.38 million ounces) of gold produced in the Republic of South Africa during the year was produced by the 34 mines that represent the membership of the Chamber of Mines of South Africa. The remainder was produced by several dozen small independent mines or as a byproduct of other mining sectors. The total ore milled by Chamber members, including ore milled by producers of byproduct and coproduct uranium, amounted to nearly 114 million metric tons or about 10 million tons more than the previous year. The average grade of ore milled during 1989 was nearly 5.0 grams per metric ton (0.146 ounce per short ton) compared with 5.13 grams per ton (0.150 ounce per ton) during 1988. Working costs for Chamber members averaged about $277 per ounce (23,340 rands per kg) and ranged from about $171 per ounce (14,407 rands per kg) at the East Driefontein Mine to about $442 per ounce (37,189 rands per kg) at East Rand Proprietary.[12] Production by the six major mining groups was as follows: Anglo American Corp. of South Africa Ltd. (AAC), 253.1 metric tons; Gold Fields of South Africa Ltd. (GFSA); 113.1 metric tons; Gencor Ltd, through its newly created subsidiary General Mining, Metals and Minerals (Genmin), 86.1 metric tons; Rand Mines Ltd., 52.4 metric tons; Anglovaal Ltd., 43.4 metric tons; and Johannesburg Consolidated Investment Co. Ltd. (JCI), 41.5 metric tons.

The largest gold mines in terms of individual output, in metric tons of gold,

TABLE 15

GOLD: WORLD MINE PRODUCTION, BY COUNTRY[1]

(Kilograms)

Country[2]	1985	1986	1987	1988[p]	1989[e]
Argentina	882	944	990	938	[3]933
Australia	[4]58,521	75,079	110,696	156,950	[3]202,900
Bolivia	561	763	2,755	4,889	[3]3,594
Botswana[e 5]	10	20	25	20	250
Brazil[e 6]	72,160	67,500	83,700	100,200	100,000
Burkina Faso[e]	1,555	1,866	6,843	10,575	8,500
Burundi	26	31	26	14	25
Cameroon	7	8	[e]8	[e]8	8
Canada	87,561	102,899	115,818	134,813	158,440
Central African Republic	188	[e]187	223	382	300
Chile	17,240	17,938	17,035	20,614	20,000
China[e]	61,000	66,000	72,000	78,000	80,000
Colombia	35,532	39,995	26,550	29,020	[3]27,090
Congo[e]	[3]16	16	16	16	16
Costa Rica[7]	498	361	300	313	350
Cote d'Ivoire (formerly Ivory Coast)	—	5	7	6	6
Dominican Republic	10,202	8,837	7,664	5,785	5,500
Ecuador	9,331	9,870	9,500	7,962	[3]9,331
Ethiopia[8]	470	923	642	728	[3]745
Fiji	1,888	2,952	2,962	4,273	4,500
Finland	595	1,172	[e]1,800	[e]2,000	2,100
France	2,127	2,382	2,225	2,525	2,600
French Guiana	249	326	514	[e]500	500
Gabon[9]	50	62	79	138	140
Germany, Federal Republic of[e]	35	35	25	15	[3]50
Ghana	9,322	8,931	10,201	11,601	[3]13,358
Guinea	—	—	[9]74	[e 10]1,300	[e 10]2,053
Guyana	321	437	1,568	[e]2,330	3,200
Honduras	156	63	131	127	130
Hungary[e]	620	560	560	560	500
India[11]	1,828	1,874	1,874	1,900	2,000
Indonesia[12]	2,619	3,300	3,654	4,734	[3]6,155
Japan	5,309	10,280	8,590	7,310	6,100
Kenya	13	73	278	17	[3]15
Korea, North[e]	5,000	5,000	5,000	5,000	5,000
Korea, Republic of[11]	2,403	4,648	7,600	11,121	12,000
Liberia[e 13]	150	625	470	[3]677	700
Madagascar[e]	4	4	[3]40	[3]90	90
Malaysia	2,809	2,718	3,512	2,929	2,860
Mali	[r]560	[r]498	700	[14]2,650	2,740
Mexico	8,264	7,795	7,988	9,098	8,300
Namibia	194	184	172	195	200
New Zealand	[r]886	1,265	1,148	2,404	2,700
Nicaragua	762	892	948	878	1,100
Papua New Guinea	36,908	35,075	33,250	38,129	35,000
Peru	6,621	8,846	8,772	9,472	[3]8,428
Philippines	33,063	40,322	32,599	35,300	35,000
Portugal	288	191	248	267	300

See footnotes at end of table.

TABLE 15—Continued

GOLD: WORLD MINE PRODUCTION, BY COUNTRY[1]

(Kilograms)

Country[2]	1985	1986	1987	1988[p]	1989[e]
Romania[e]	2,000	1,900	1,900	1,900	1,750
Rwanda	7	6	10	[r]9	10
Saudi Arabia[e]	—	—	—	1,000	3,000
Sierra Leone[15]	591	373	467	404	400
Solomon Islands	65	98	[r]124	47	—
South Africa, Republic of	670,754	638,047	596,456	618,369	603,000
Spain	5,770	5,200	5,008	[r]5,132	5,000
Sudan[e]	[r]55	[r]70	[3]85	[3]500	500
Suriname[e]	15	20	22	[r]30	[3]31
Sweden[e]	[3]4,631	4,040	4,040	4,200	4,000
Taiwan[11]	953	910	533	236	250
Tanzania	55	85	201	52	100
U.S.S.R.[e]	270,000	275,000	275,000	280,000	285,000
United States	75,495	116,296	153,870	200,914	[3]265,541
Venezuela	2,307	2,494	3,860	3,673	[3]3,900
Yugoslavia	[r]3,420	3,583	5,348	4,620	4,500
Zaire	1,960	5,220	4,372	3,563	3,500
Zambia[16]	285	268	356	227	250
Zimbabwe	14,691	14,853	14,710	14,191	14,500
Total	1,531,858	1,602,215	1,658,142	1,847,840	1,971,004

[e] Estimated. [p] Preliminary. [r] Revised.

[1] Table includes data available through May 30, 1990.

[2] Gold is also produced in Burma, Cuba, Czechoslovakia, the German Democratic Republic, Norway, Senegal, Thailand, and several other countries. However, available data are insufficient to make reliable output estimates. Poland annually mines and processes copper ore estimated to contain about 31,000 kilograms of gold. Disposition of the gold byproduct is unknown.

[3] Reported figure.

[4] Excludes gold in gold ore and concentrate from South Australia.

[5] Only the combined total of gold and silver production is reported, which for this table is estimated to be divided thus: 83.5% gold-16.5% silver, the approximate ratio for combined 1982–83 production.

[6] Officially reported figures are as follows, in kilograms: Major mines: 1985—7,597; 1986—9,348; 1987—13,120; 1988—24,012 (estimated); and 1989—24,900 (estimated). Small mines (garimpos): 1985—22,076; 1986—14,776; 1987—22,660; 1988—55,053 (estimated); and 1989—56,000 (estimated).

[7] Gold purchased by Banco Central from placer deposits and mines; actual production estimated to be at least twice this amount.

[8] Year ending June 30 of year listed.

[9] Does not include undocumented production from small artisanal production

[10] Figures include reported mine production of 320 kilograms in 1988 and 1,059 kilograms in 1989. Remainder represents approximate reported sales to Government of artisanal production. Figures do not include artisanal production smuggled out of country.

[11] Refinery output.

[12] Excludes production from so-called people's mines, estimated at 15,000 kilograms per year during 1986–89, but includes gold recovered as byproduct of copper mining.

[13] These figures are based on gold taxed for export and include gold entering Liberia undocumented from Guinea and Sierra Leone.

[14] Includes production from Kalana Mine, artisanal production and undocumented gold entering Mali.

[15] Data are based on official exports and do not reflect gold moved through undocumented channels.

[16] Year beginning Apr. 1 of year listed.

included AAC's Freegold Mine with 110.9, Vaal Reefs with 75.5, Driefontein with 54.4, Western Deep Levels with 40.6, and Hartebeestfontein with 31.2.

In mid-December, Rand Mines poured its first bar of gold at its new Barbrook Mine near Barberton in the Orange Free State (OFS). Barbrook is the first grass-roots mine opened by Rand Mines in many years. In late 1989, Genmin announced plans to proceed with the development of its new Weltevreden Mine near Orkney in the OFS. The new mine, scheduled to begin production in the second half of 1992, was expected to extract ore from the gold-bearing Vendersdorp Contact Reef. A relatively shallow mine by South African standards, Wellevreden's ore will be extracted using low-cost trackless mining methods operating from 100 to 1,100 meters below the surface.

CURRENT RESEARCH

The Bureau of Mines conducts research into various aspects of the gold mining industry.[13] Because gold mining is pursued in many nations, the results of this ongoing work may, like the Bureau's earlier work in heap leaching, ultimately benefit a broad segment of the industry worldwide. The Bureau's current research relating to gold mining generally focused on the use of cyanide in the recovery process. Through its work, the Bureau addressed several questions regarding the use of cyanide, its long- and short-term persistence, and effects in the environment. These questions included such topics as the persistence of cyanide, the mass balance of cyanide in the leaching process, the mobility of metals in the heap during heap leaching, and the protection of wildlife.

The Bureau sponsored university research through its mineral industry waste treatment and recovery generic center. A joint Bureau-university-industry effort was recently commissioned to assist in defining future environmental needs relating to gold mining and cyanide use. Six priority areas chosen for research included the following: mine and mill closure, cyanide destruction, seepage, wildlife protection, acid mine drainage, and cyanide alternatives.

Several reports on research relating to gold were issued by the Bureau during 1989.[14]

OUTLOOK

As an internationally traded commodity serving not only the industrial and jewelry end use sectors but the investment sector as well, the outlook for gold supply and demand must be viewed from a global viewpoint.

Gold Fields Mineral Services[15] in its annual review of supply and demand, acknowledges the pitfalls of long-term forecasting by limiting its outlook to the immediate future. Gold Fields, in addressing the outlook for prices greater than those achieved near yearend, noted that several underlying factors favoring a higher price were evident. These factors included their forecast for a levelling-off of mine production in the market econ-

omy countries during the early 1990's and a lower level of accelerated supplies from other sources such as the gold loans and forward sales that were featured most prominently during 1988. Gold production in the U.S.S.R. may decline during the present economic crisis while pressure to sell gold to raise foreign exchange will continue. Sales of gold by central banks and sales of bullion coin holdings by European investors may be somewhat less than in 1989 and the amount of scrap entering the market should remain at the present low level.

Gold Fields concluded its supply forecast by stating that, in the absence of exceptional sales from CPE countries, the record supply level of 1989 is unlikely to be repeated in the immediate future. On the demand side, Gold Fields expects that the rate of growth in jewelry demand of the past 3 years may decline as consumer spending slows. Similarly, an expected decline in physical bar hoarding in Brazil and Some Far Eastern Nations may be softened by increased demand from the Republic of Vietnam.

If the price of gold remains at levels acceptable to the domestic mining industry, gold production may be expected to grow, but at a slower rate than that of the past several years. The hectic pace of exploration seen in recent years appears to have peaked or at least shifted somewhat toward the base metals. Many small mines opened in recent years will probably close as their limited ore reserves are depleted. This loss in production will probably be offset by some new mines and especially expanded production at established larger mines where the focus has shifted toward exploiting their large reserves of gold-bearing sulfide ores. Any growth in production must assume, of course, that a relatively stable and predicatable regulatory climate will continue to prevail.

On the demand side, the near-term outlook for continued strength in the all-important jewelry sector depends on a number of unpredictable factors such as the continuance of acceptable gold prices, variable fashion trends, and the continued success of industry product advertising to attract new jewelry buyers. Jewelry demand may level off somewhat in the near term as discretionary consumer funds tighten. The use of gold in electronic applications may experience continued growth as the demand, for sophisticated and more reliable electronic goods expands to match the growth of the gross national product. Gold has a number of unique characteristics that favor its continued usage in dental applications; its usage in dentistry should probably remain at or near the present level despite the continued impact of cheaper substitute materials.

BACKGROUND

Gold lore and the use of gold predates written history. Gold has been considered a precious metal since ancient times, and the search for gold has stimulated world exploration and world trade for more than 60 centuries.

Gold mining in the United States began about 1800 in North Carolina, with Georgia becoming a producer in 1829 and Alabama in 1830; Virginia, Tennessee, and later New Mexico began producing as prospectors moved west. The most important gold discovery, because of its influence on development in the Western United States as well as on the amount of gold produced, was at Sutter's Mill in California in 1848. Later discoveries were made in most other Western States and territories.

Gold mining in Australia began about 1849 as an offshoot of the California gold rush. Russian gold mining had been expanding since the mid-18th century, and by the eve of the California gold rush, Russia was producing nearly two-thirds of the world's gold. Gold mining in the Republic of South Africa started in the 1870's. The last major gold rush began just before to 1900 in Canada's Yukon and in Alaska.

Early mining was largely by placer methods with a multitude of miners working stream deposits (placers) by hand mining techniques, a practice that continues to this day in many areas of the world. In the 1860's, the more difficult underground mining of lode deposits—the sources of the placers—became important. Cyanidation, a chemical process for gold extraction, was introduced about 1890. The concentration of finely ground ores by the flotation process, selective adherence of mineral particles to rising bubbles, was first used for gold ores around 1900 and came into general use in the 1930's. Heap leaching, essentially a form of cyanidation, has come into general practice for treatment of low-grade ores only during the past two decades.

Cumulative world production to date is estimated at about 105,000 metric tons (3.4 billion ounces), about two-thirds of it mined in the past 60 years. The total is equivalent to a cube roughly 18 meters (58 feet) on a side. The Republic of South Africa has been the source of about 41% of that gold, but nearly all countries have reported at least some production of gold.

U.S. gold production from its beginning in the 18th century to date totals nearly 11,000 metric tons (353 million ounces). The principal producing States, in declining order of cumulative production are: California, Nevada, Colorado, South Dakota, Alaska, Utah, and Montana; the remainder came from 11 other States. To date, lode gold mining has supplied about 50% of U.S. production, placer mining 35%, and base metal mining 15%. The Homestake Mine at Lead, SD, has accounted for about 10% of all U.S. gold production. Other major sources of past production include the Mother Lode and Grass Valley areas of California, the Comstock Lode and Goldfield areas in Nevada, Cripple Creek in Colorado, and the Fairbanks and Nome, AK, areas.

Most domestic gold mines were closed by Limitation Order L-208 in the early months of World War II so that scarce equipment, supplies, and skilled manpower could be focused on mining essential base metals. Because of increased cost and rehabilitation problems, only a few reopened after the war; however, during the resurgence of gold exploration and mining over the past decade, many deposits affected by L-208 have been reexamined or returned to productive status.

Definitions

Gold has an atomic number of 79 and an atomic weight of 197, occurring naturally as a single stable isotope. Its melting point is 1,063° C and its specific gravity is 19.3. In addition to being highly resistant to corrosion, gold is also extremely malleable and ductile; 31 grams (1 troy ounce) can be beaten into about 250 square feet of gold leaf about four-millionths of an

inch thick while a similar quantity can be drawn into a wire more than 80 km (50 miles) long.

As an illustration of gold's high specific gravity or density, 1 cubic foot of pure gold weighs a little more than 1,200 pounds, one cubic inch of pure gold weighs about 311 grams (10 troy ounces), and a lump or nugget of gold the size of a navy bean weighs about 3 grams (0.1 troy ounce).

The troy system of weights is generally used in the United States for gold and other precious metals; however, to aid in harmonizing world data collection, Government practice now requires the use of the metric system of measure. Thus, outside of the Government, either system may be encountered. The troy weight system is based on the troy ounce of 480 grains or 20 pennyweight. One troy ounce is equivalent to 1.097 ounces avoirdupois. Many nations use the metric system; under this system, the weight of gold may be designated in standard metric terms; gram, kilogram, or metric ton. The metric ton is equivalent to 32,150.7 troy ounces.

Fineness refers to the weight proportion of pure gold in an alloy, expressed in parts per thousand; 1,000 fine gold is 100%-pure gold. Commercially traded gold bullion is usually 995 fine or higher. The term "fine gold" may also be used to designate the particle size of gold in its native state; for example, a placer deposit with gold particles ranging from 0.38 milimeter (mm) to 0.76 mm (0.015 to 0.03 inch) in diameter contains fine gold, whereas a similar deposit with particles more than 1.5 mm (0.06 inch) in diameter contains coarse gold.

The term "karat," like fineness, refers to purity, but is expressed in 24ths; thus 24-karat (24k) gold is 1,000 fine or pure gold, and 10k gold is 10/24, or 41.7% gold. Although there are many 10k alloys, each 10k alloy contains 41.7% gold. Various 10k alloys, for example, differ from each other in the number, identity, and proportions of their other constituent metals. Gold alloys used in jewelry and certain other end uses are referred to as karat golds, whereas alloys used in dentistry and electrical devices are designated more precisely. Yellow, red, and green karat golds are essentially ternary alloys of gold, silver, and copper, often with additions of zinc and sometimes a little nickel. White karat golds are usually composed of gold, copper, nickel and zinc, although platinum and palladium have also been used as components.

Refined gold bullion bars destined for monetary, investment, and industrial usage are generally designated as "Good Delivery Bars." The unit of trading on the London Gold Market is a bar measuring about 17.8 centimeters (cm) by 9.2 cm by 4.1 cm (7 inches by 3⅝ inches by 1⅝ inches) thick weighing approximately 12.5 kg (400 troy ounces or about 27 pounds), having a minimum fineness of 995, and bearing a weight stamp, serial number, melt number, and the stamp of an acceptable melter or assayer. Smaller bars for use by investors as well as industrial users are also commonly available on the commercial gold market.

U.S. trade practice rules for the jewelry industry, set by the Federal Trade Commission, require that any article labeled gold must contain at least 10k gold, with a tolerance of three parts per thousand for most articles, or if soldered, to seven parts per thousand. Rolled gold plate and gold filled are terms referring to articles made of base metal to which karat gold has been bonded by soldering, brazing, welding, or mechanical means. A marking such as "1/10 10-karat gold filled" means that one or more surfaces are covered with 10-karat gold and the coating constitutes at least 10% of the weight of the entire article covered. No article may be marked "gold filled" if its karat gold surface constitutes less than 1/20 of the total weight. Thinner coatings are marked "rolled gold plate.

Products for Trade and Industry

Although gold compounds are used in substantial quantities in electroplating, most of the gold sold in the international marketplace for industrial usage is in the form of metal or metal alloys. Many standard metallic forms are available, such as bar, rod, sheet, foil, wire, powder, granule, and shot. Pastes and inks prepared with gold powder are widely employed in the electronics industry. Much jewelry gold is supplied as granules of specified karat content. Semimanufactured items for trade and industry may include gold jewelry findings or unassembled parts such as earring clamps, chain clasps, pins, etc.; dental findings; and inlaid, clad, and plated metals. Investment products such as bars, coins, and medallions are manufactured and sold by both industry and by governments.

Industry Structure

In the United States during 1989, 89% of domestic production came from gold ore, and most of the remainder was a byproduct of silver or copper and other base metal production. Placer gold production has declined to about 2% of the reported total production in recent years. Sixteen mines accounted for about 61% of domestic output in 1989; 80% came from mines in Nevada, California, Montana, and South Dakota. The leading producer in most recent years, Newmont Gold Co., provided about 17% of domestic output from its surface operations near Carlin, Nevada. The Homestake Mine, a deep underground mine in South Dakota, has been an alternate leading producer for many years. The Utah Copper Division of Kennecott, a major copper producer, has been a significant gold producer in many years since 1979, a year when it was the Nation's largest gold producer. Kennecott's gold is a byproduct of its extensive copper mining operations at Bingham Canyon, UT. Freeport-McMoRan Gold Co.'s Enfield Bell (Jerritt Canyon) Mine, a large open pit operation in north-central Nevada that began production in 1981, was the fourth-largest producer in 1989.

Attracted by the favorable U.S. business climate, foreign investment in domestic firms that produce gold as a principal product or as a byproduct has increased since 1980. This is especially true for mining interests acquired by multinational companies, some of which in turn may be directly linked to foreign governments. The general attractiveness of the United States as a country in which to conduct business has been a principal motive behind these acquisitions. Canadian mining companies have, throughout the history of North American mining, operated mines in the United States, as to a lesser extent, have British and other European companies.

The South African gold mining industry, accounting for about 30% of current world output, consists of about 3 dozen large underground operations

and several dozen smaller mines. In a typical year, the Republic of South Africa's gold industry reportedly mills enough ore to cover 60 city blocks to a height of 20 stories; from this volume is recovered enough gold to fill a small room. These mines are owned or controlled by six corporations, which interlock through directorships and mutual shareholdings and have extensive mineral and industrial investments in many parts of the world. The corporations are; Anglo American Corp. of South Africa, Ltd.; Anglovaal Ltd.; Gencor Ltd.; Gold Fields of South Africa, Ltd.; Johannesburg Consolidated Investment Co. Ltd.; and Rand Mines Ltd.

Geology

The Earth's crust has been estimated to have an average gold content of about 0.0034 gram per metric ton (0.0001 ounce per short ton), or 3.5 parts per billion (ppb). Sedimentary rocks, especially sandstones, tend toward higher than average gold content. In igneous rocks, the content averages slightly higher in darkly colored mafic rocks than in lighter colored felsic rocks. Seawater typicaily contains about 0.011 ppb gold; however, content varies widely with location and may range from 0.001 to 44 ppb. Numerous attempts have been made over the years to recover gold from seawater; however, none have been commercially sustainable. The gold content in surface and ground waters lies within the range of analyses for seawater, but varies widely depending on source. For instance, waters from gold mines in southern Yakut, U.S.S.R., contain an average of 0.7 to 0.9 ppb. In Colorado, waters draining from gold mining and other areas contain up to 0.15 ppb, but with no distinct differences between gold-enriched and gold-barren areas. Hot-spring waters generally contain more gold than other waters.

Gold deposits are found in many kinds of rock. Hydrothermal deposits appear to be somewhat more common in acidic and intermediate igneous rocks, in silty, laminated carbonate rocks, and in silicious or aluminous sedimentary or metamorphic rocks. The general deposit types include hydrothermal, hydrothermal-metamorphic, metamorphic, replacement (lode, massive, and disseminated), and cavity filling (fissures, stockworks, saddle, reefs, breccias, and conglomerates).

Gold occurs mainly as native metal, alloyed with silver and/or other metals, and as tellurides. A naturally occurring alloy of gold and silver is known as electrum. Other gold minerals are rare. Gold is commonly associated with the sulfides of iron, silver, arsenic, antimony, and copper.

Chemical and mechanical weathering and erosion cause gold in the free or metallic form to be released from lode or primary deposits and to accumulate as nuggets and grains in residual deposits or placer deposits. Although the richest lode gold deposits have been small fissure vein types with quartz gangue, the so-called bonanzas, much larger quantities have been mined from large, medium-grade deposits. U.S. gold ores average about 3.5 grams per metric ton (0.1 ounce per short ton), or less; however, the advent of chemical heap leaching now makes it possible for rock with suitable properties containing considerably less than 3.5 grams per metric ton to be considered ore.

Technology

Exploration.—Although a number of new techniques have come into use in the exploration for gold, the gold pan remains one of the simplest and most efficient low-cost means of finding visible gold and tracing it to its source. Collecting, crushing, and panning quartz samples from geologically favorable areas is a common basic procedure employed in prospecting for bonanza-type lode deposits. Neutron activation analysis and atomic absorption spectroscopy permit relatively fast and reliable gold analyses and have had an important bearing on the ability of field geologists to do geochemical surveys of areas formerly of little interest because of sampling costs and lack of outcrops. The long-established fire assaying technique, however, continues to be the most widely used method for determining the quantity of gold present in samples or market products where precision and accuracy of the results are important. Newmont Gold Co. recently initiated an automatic assay system whereby more than 4,900 laser-read barcoded samples are directed daily through the various laboratory stages with the aid of computers. Geochemical studies have established relationships between gold and other elements, such as tellurium, mercury, arsenic, and copper, which can be useful trace elements in the search for gold. In recent years computers have proven to be useful in determining the often subtle relationships between trace elements and gold mineralization. Metallogenic studies relating tectonic histories and regional and local geology have given better understanding of where important gold deposits may lie.

Wire-line core drilling and improved percussion drilling methods have reduced the costs and increased efficiencies of exploration and development. Research on sampling through statistical analysis techniques that take into account the distribution and size of gold particles in a sample has shown ways to effectively reduce sampling costs. Computer methods have been useful in defining the extent of pay zones in larger ore bodies, such as those in the Republic of South Africa, and have application to low-grade disseminated deposits. Improvements in mining machinery and procedures and the introduction of new gold leaching methods have combined to lower the economic cutoff limits for gold deposits, providing an impetus for extensive reevaluation of previously mined areas as well as the incentives necessary to encourage the exploration of new, heretofore unproductive, areas.

An issue of continuing concern to domestic gold producers and to producers of other minerals as well is that of mineral land availability. Because the geological forces that form mountains and unique physiographic features are often responsible for producing mineral deposits, exploration for gold and other minerals frequently focuses on these areas of disturbance. The same rugged features that make certain areas attractive to the minerals explorer may also make them less accessible for mining because these areas may be more valued for their undisturbed, or wilderness, qualities than for their mineral potential. In recent years, the trend toward preserving increasingly greater areas of unevaluated wilderness land, on which exploration is prohibited or severely restricted, may lead to a decline in new discoveries as well as jeopardize national security.

Mining.—The technology of gold mining is well established, having

evolved largely over the past century. Much of the world's gold production has come from deep narrow veins or from thin-bedded layers called reefs; these have been difficult to mine (in the Republic of South Africa, for example) because of high underground temperature, humidity, and extreme rock pressure, which often causes dangerous rock bursts. Most domestic gold comes from surface lode mines.

Placer mining was once an important source of gold. Dredging offers the maximum efficiency in large alluvial or marine deposits; dragline, hydraulic, or bulldozing methods are commonly used in smaller, bouldery deposits. Most placer mining requires large quantities of water, but dry operation is also possible, using bellows or other air-blowing equipment for separation. However, recovery efficiency may be lower in dry processing. For large-scale, open pit lode gold mining, computer models have been developed to analyze various production factors and establish optimum pit configurations and extraction efficiencies.

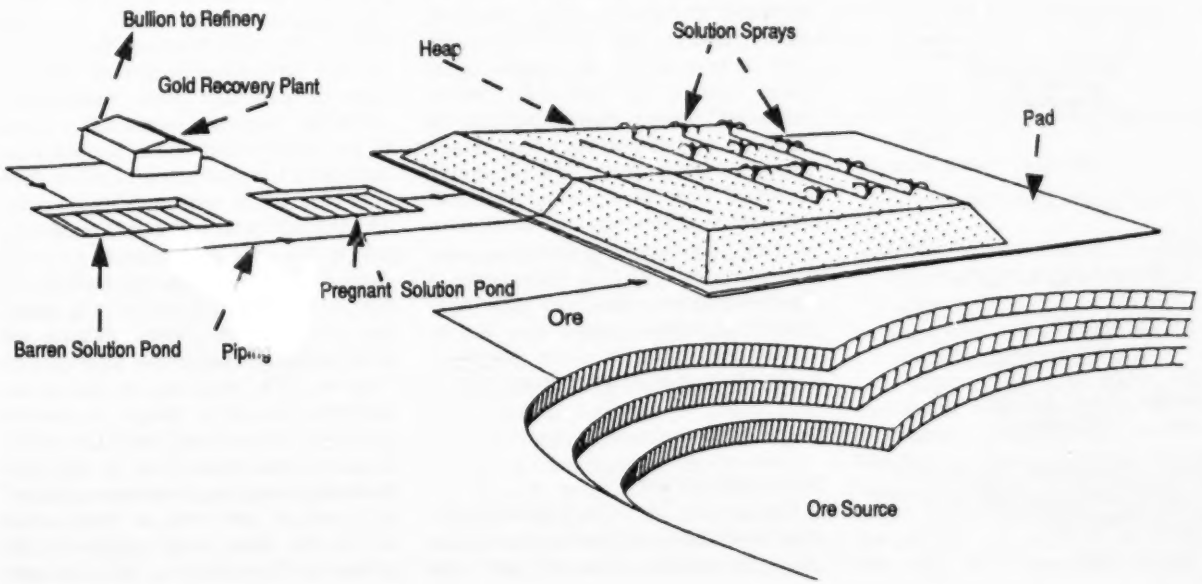
The South African mining industry, a leader in deepmining technology for many years, has evolved new methods of controlling problems relating to rock stress, dust, and stope temperature. Both large and small water-powered rock drills, large-diameter raiseboring machines, and new types of rubber tired transporters have been developed in recent years to increase the efficiency of mining operations. Also, the South Africans have developed new techniques of shaft sinking, mineral processing, and extraction that are critical to the success of deep mining. At the Vaal Reefs Mine, for example, part of the gold ore is transported to the surface from a depth of more than 2100 meters (7,000 feet) by hydraulic pumps.

Beneficiation.—Milling technology for gold is highly developed, and normal mill recovery rates may range from 92% to 96%. Gold is recovered by cyanide leaching of gold ore contained in tanks or heaped on impervious leaching pads or by amalgamation, flotation, gravity concentration, and smelting, or by a combination of these processes. Heap-leach process components are shown in figures 1 and 2. Increased exploitation of gold-bearing sulfide ores in recent years has led to the development and application of several technologies designed to render sulfide and refractory ores amenable to cyanide leaching; thus, process steps such as autoclaving, biological preoxidation, or fluid-bed roasting have recently been incorporated at a number of milling operations.

Smelting.—Many gold mining operations recover gold from cyanide leach solutions by precipitation with zinc dust, though in recent years, carbon-in-pulp (CIP) recovery technology has been adopted at a number of new mining operations. With CIP, activated carbon made from coconut shells or other durable carbon sources collects gold from the cyanided pulp until it contains 10 to 12 kg (300 to 400 ounces) of gold per ton of carbon. Gold with accompanying silver is desorbed or stripped from the carbon with a strong alkaline cyanide-alcohol solution. The precious metals are recovered from the strip solutions by electrodeposition on a stainless steel wool cathode. The cathode deposit is then refined into bullion or doré, a mixture of mostly gold and silver. The carbon is reused after being screen-sized and reactivated through controlled roasting. Generally, gold recoveries range from 92% to 97% of the feed content. Gold leaching processes in use or under development that do not employ cyanide as the principal lixiviant or dissolution medium include the application of thiourea, iodine, malonitrile, or various bioextraction

FIGURE 1

HEAP-LEACH PROCESS COMPONENTS



techniques. Some of these alternate techniques, unlike the long-established, well-understood cyanide process however, may be accompanied by unacceptable cost or environmental burdens. When gold is associated with copper ores, it travels with the base metal through concentration and smelting to the refining stage. It is eventually separated from the anode slimes that accumulate in electrolytic copper refining cells and is recovered as gold bullion in the precious metals refinery. Gold losses in concentrating copper ores are about the same as for copper, but are negligible in smelting and refining.

Gold is refined by chlorination in the molten state (Miller process) and by electrolysis (Wohlwill process). Generally, gold bullion made by the Miller process is 996 to 997 fine, and bullion made by the Wohlwill process is 999.5 to 999.8 fine.

Recycling.—Because of its high intrinsic value, gold has been recycled throughout the ages. Thus, a modern article of jewelry containing recycled gold could conceivably contain atoms of gold from a golden earring worn by Helen of Troy or from a nugget of gold used in the year 4000 B.C. to barter for ingots of crude copper or other goods at a Mediterranean seaport.

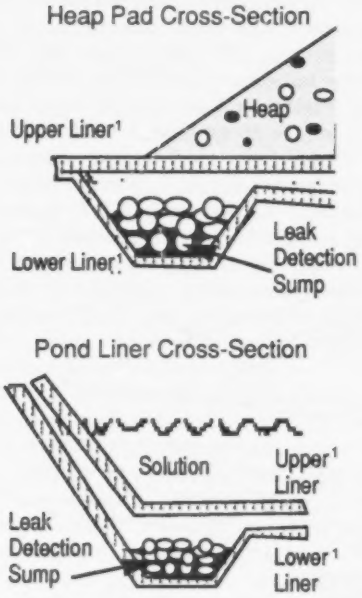
Precious metals refiners throughout the world recover gold from scrap. In the United States, about 60% of the scrap comes from current manufacturing operations, and the remainder comes from old scrap in the form of items such as discarded jewelry and dental materials, used plating solutions, junked electronic equipment, etc. Gold is so valuable that even the gloves, aprons, and dust masks worn by gold workers and the dust or "sweeps" from their shops may be processed to yield payable quantities of metal. Similarly, a specialized field of secondary gold recovery focuses on gleaning gold from defunct gold processing operations. Most domestic scrap processors are located in the Northeastern States.

The general flow of gold in the secondary industry is shown in figure 3. Refiners receive scrap in a variety of forms and determine processing steps according to batch size, average gold content, and the impurities to be separated. Scrap dealers and semi-refiners may process the scrap and then ship the upgraded product elsewhere, including overseas, for further treatment and refining. Scrap is either purchased outright or treated on a toll basis.

A considerable quantity of scrap is generated in manufacturing operations, but because of tight security controls over waste materials in precious metals plants, nearly all of this "home-generated" scrap is recovered. Some old scrap, on the other hand, is lost because in practice gold cannot be economically recovered from all manufactured products; this is increasingly true as miniaturization of gold-bearing electronic products proceeds. The U.S. Department of Defense recovers a significant quantity of gold from military scrap; other Federal Government agencies either participate in the Defense recovery program or have their own.

FIGURE 2

HEAP AND POND LINER CROSS SECTIONS



[1]Liners, High density, polyethylene or polyvinyl chloride 1 mm to 2.5 mm thick (60-100 mils)

Economic Factors

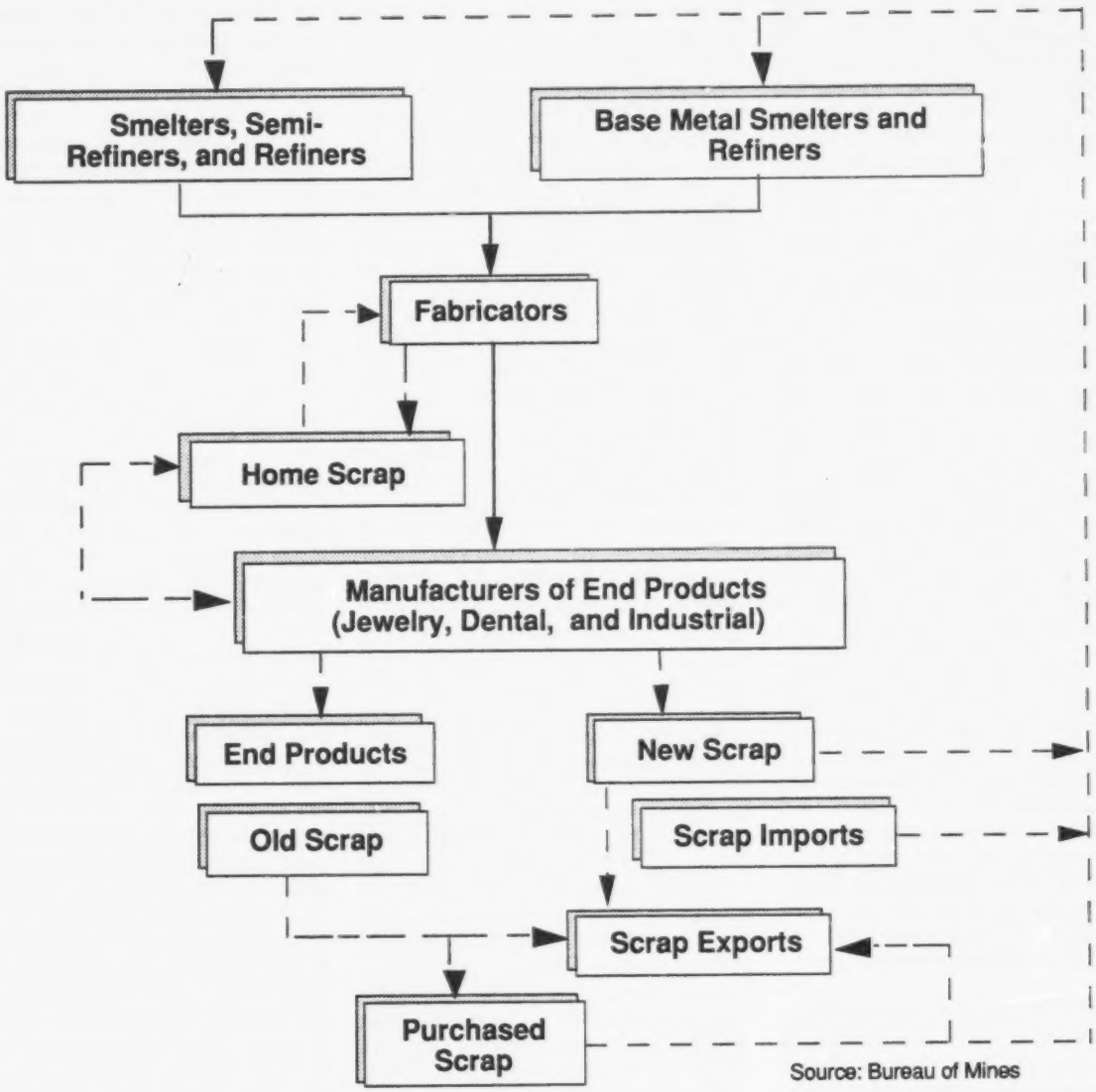
On January 31, 1934, following provisions of the Gold Reserve Act of that year, the official price of gold was raised by the U.S. Government from $20.67 per ounce to $35 per ounce. The value of $1 was thus established at 28.57 thousandths of a troy ounce, and gold flowed into the United States. By 1949, gold stocks held by the U.S. Department of the Treasury had risen to a peak of 21,708 metric tons (698 million ounces).

During the 1950's and 1960's, foreign central banks vigorously exchanged their large dollar holdings for U.S. gold. Consequently, U.S. stocks declined, with much of the gold accumulating in stocks owned by foreign governments. When the outflow of gold was finally stemmed in August 1971 by a Presidental order ending the convertibility of U.S. dollars into gold, U.S. stocks stood at 9,069 metric tons (291.6 million ounces). Thereafter, U.S. stocks declined somewhat, reflecting gold auctioned by the Department of the Treasury in 1975, 1978, and 1979 and later minting of gold coins and medallions for public sale. At yearend 1989, U.S. Treasury stocks stood at 8,146 metric tons (262 million ounces).

Because of increasingly severe pressures on official gold reserves stemming from attempts by monetary agencies to hold the price of gold down to $35 per ounce, a seven-nation International Gold Pool established a two-tier price system in March 1968. Under this system, there was an official price of $35 on monetary transactions, thenceforth restricted to Government-owned gold, and an open market price for other transactions, which could fluctuate with supply and demand. Since then, the free market has flourished, and the price of gold has risen dramatically, while the monetary sector has evolved to the point where most nations conduct gold transactions and value their gold reserves at market-related prices. The United States is the only remaining holder of large gold reserves to value them at the low official price of $42.22 per ounce. The U.S. dollar was devalued twice in the 1970's, raising the dollar price of gold to $38 an ounce on May 8, 1972, and then to $42.22 on October 18, 1973, where it remains today. With the second devaluation, the President was empowered to eliminate regulations on the private ownership of gold, which had been in force since 1934, and these were eventually removed on December 31, 1974. January

FIGURE 3

SECONDARY GOLD CHART



Source: Bureau of Mines

2, 1975, was the first day that the general public was allowed to resume holding gold without a licence issued by the U.S. Treasury's Office of Domestic Gold and Silver Operations; the office was closed on July 31, 1975.

Trading in gold futures began in New York and Chicago upon restitution of the right to private ownership of gold. Trading volume has increased nearly sixteenfold since 1975, peaking at nearly 43,000 metric tons (1,380 million ounces) in 1982; the volume in subsequent years has ranged from about 25,000 to nearly 35,000 metric tons. However, only a small percentage of the gold traded enters the physical market.

Because of gold's monetary role and the fixed $35-per-ounce price from 1934 to 1968, domestic producers had difficulty maintaining production in the face of rising costs. Gold was particularly attractive as a commercial metal because its price was stable and a dependable domestic supply was provided to industrial users by the U.S. Treasury until March 17, 1968.

In March 1982, the U.S. Gold Commission, which had earlier convened to consider a renewed role for gold in the U.S. economy, concluded that reintroduction of gold into the current monetary system would probably not serve to alleviate potential economic problems such as inflation. The prospects for a return to a gold standard in other countries would also seem to be uncertain. However, as a so-called "hard cur-

rency," gold may come to enjoy a greater role in world economics, than it has in the recent past. This is especially important as the world economic system adjusts to accommodate rapidly changing political, economic, and trade practices and to address the many issues associated with the rapid growth in world population, dwindling resources, and slower growth in industrial productivity. Small-scale bartering arrangements involving gold continue as they have for centuries, especially in frontier mining areas such as those in South America, Africa, the western Pacific, and remote areas of North America.

An issue of increasing concern to the mining industry as well as Federal, State, and local law enforcement authorities has been the recent growth in telemarketing fraud and investment swindles involving sales of gold bullion and investment in questionable mining ventures. In late 1988, the North American Securities Administrators Association Inc. (NASAA) and the Council of Better Business Bureaus Inc. issued an Investor Alert entitled "Dirt Pile Gold Swindles." The alert was to educate the public regarding the organization, characteristics, and pitfalls of the classic "dirt pile" or "gold-in-the-ground" swindle. The NASAA is composed of representatives from the securities regulatory agencies of all 50 States plus Puerto Rico. Law enforcement authorities and various industry trade groups continue to police against other fraudulent practices such as misrepresented gold quality marks on jewelry and bullion and faked collector coins.

Prices.—The price of gold is a topic of continuing concern and interest to the producer and the consumer of gold alike; where it has been, where it will go, and the reasons behind its wild fluctuations over the past decade or so have been studied from every angle by numerous observers. Apparent causes for the price changes have been presented, and speculation on their future directions have been offered.

Unfortunately, many of these sophisticated econometric models forecasting the price using combinations of economic, political, and social factors that proliferated in the early 1980's had all but disappeared from the public domain by the end of the decade. The course of future events cannot, of course, be forecast with accuracy, nor can the price of gold. Forecasting gold's price is unusually complicated because gold occupies a unique position among the world's commodities. Gold is both an internationally traded commodity and, at the same time, a long-established, universally acceptable storehouse of value, considered by many people worldwide to be superior to fiat paper currencies with fleeting longevity or fluctuating unpredictable value. Unlike many commodity prices that are more or less tied directly to supply and industrial demand, the price of gold cannot be viewed as one would view the price of other goods or services in a free market. Gold also cannot be viewed strictly from the standpoint of the U.S. market alone, for international, political, and economic events that may impose a positive or negative influence on gold the commodity may be overshadowed by developments perceived to favor gold the medium of exchange. For example, citizens of nations that have been invaded by other countries during the course of their history tend to value the monetary and exchange aspects of gold more highly than countries such as the U.S., where this has not been the case. To them, gold is money or the preferred substance of wealth, and the ownership of even a small amount of physical metal ensures escape or a new beginning. Therefore, many individuals worldwide, as a matter of tradition or simple prudence, continue to hold small quantities of gold in the form of jewelry, coins, nuggets, etc., legally or illegally, as a portable form of universally accepted capital; for some, especially in developing countries, gold may constitute the only available and relatively risk-free form of old age or disaster insurance.

Although the average price has declined from its record 1980 level of $612 per ounce, it remains considerably higher than the prices of the early 1970's. This high price level, not generally enjoyed in recent years by many other commodities, continues to spark investor interest and lead to an overall sustained increase in the level of funding available to gold producers to invest in exploration and productive capacity. The heightened interest in gold has, as in the past, promoted exploration of those remote corners of the Earth where exploration for other less valuable minerals could not be justified but where their serendipitous discovery as a byproduct of exploration for gold is likely to eventually contribute to the needs of society.

In the fabrication of gold, particularly in the electronic and electrical industries, the cost of gold used per unit item is still such a small percentage of the total unit cost that the price for gold is often of small significance in pricing the product. Some industrial consumers of gold, however, confronted with unpredictable and potentially ruinous prices, have turned in recent years to the various world futures markets to ensure that their future gold requirements will be available at preselected prices.

Costs.—Costs of mining gold in the United States range upward from costs typical of low-cost placer mining, where dredging or hydraulic operations are conducted profitably on gravels containing less than 0.49 gram per cubic metric (0.01 ounce of gold per cubic yard). Surface lode mining, although considerably more expensive than placer mining, is profitable with some ores containing as little as 0.3 gram of gold per metric ton (0.09 ounce per ton), depending on the stripping ratio, size and type of operation, the characteristics of the ore processed, and the mine's location with respect to the duration of the operational season and the infrastructural requirements. Underground mining for gold is the most expensive mining, but costs vary greatly from mine to mine; nevertheless, some underground mines are able to produce an ounce of gold at costs below those of some surface operation; for example, the average cost to produce an ounce of gold at the 2400-meter-deep (8,000 ft) Homestake Mine in South Dakota, including a small contribution from a new surface pit, during 1989 was $322. The cost was distributed as follows: mining and treatment, $287; administrative and general $16; and taxes $19.

Costs for processing gold ores can vary widely, depending on the treatment required. Recent advances in heap leaching of gold and extraction with activated carbon may afford lower capital and operating costs than those associated

with conventional cyanidation. One recent advance, for example, is particle agglomeration, a technique developed and patented by the Bureau of Mines to increase the flow rate of leaching solutions through crushed ore. Fine particles in the ore that would otherwise impede solution flow are bound together or agglomerated through the addition of a water-soluble binder such as a cement or lime. Other innovative techniques developed in recent years to improve the efficiency of the heap-leaching process include the use of ore conveyors and stackers, solution heaters, and improved solution distribution and recovery and leak detection systems. Other advantages of heap leaching over conventional milling include shorter plant construction time and greater adaptability to lower-grade ores. A disadvantage of conventional heap leaching is lowered recovery, usually 60% to 80% of the gold present, compared with 88% to 92% or greater recovered by conventional mill treatment. The recovery efficiency of heap-leaching operations where agglomeration technology is employed approaches that of conventional methods.

Some producers, by forward selling of their future gold production, are able to maintain economic production even during periods when their production costs may exceed the existing market price of gold.

Taxes.—Taxes may be levied on mining operations for gold and other minerals at the Federal, State, and local levels. In addition to the usual business, occupation, and property taxes and licence fees required of all business enterprises, mining operations in many States are subject to severance or extraction taxes imposed on the yield or proceeds received from the sale of newly mined products. In 1989, the State of Nevada, for example, increased the net profits tax on State mineral production from about 2% to 5%. In 1986, a new Federal tax, the Customs User Fee, was adopted; it places a 0.22% levy on all imports, including gold and gold-bearing products. The fee was reduced to 0.17% on September 30, 1987.

Most major gold-producing nations impose taxes on domestic mining operations; taxation of the gold mining industry in some countries may be specifically tailored to accommodate a nation's stated economic and political objectives. For example, in the Republic of South Africa gold mines are taxed in accordance with two basic formulas: one taxes the profits of mines opened before to 1966, while the other formula applies to newer mines. Many major gold-producing nations have also provided tax concessions, subsidies, and others assistance to gold mining. The U.S.S.R. has supported gold mining through administrative fiat. China encourages gold prospecting by both the civilian and military population. Australian mining companies have for decades been exempted from paying taxes on profits derived from gold mining. However, effective January 1, 1991, the Government of Australia will eliminate its six-decade-old tax exemption for income derived from gold production, including byproduct production from copper operations where gold represents more than 40% of the total income.

Operating Factors

Environmental Requirements.—The costs associated with meeting various Federal, State, and local environmental requirements can vary considerably from one mine site to another. At mines utilizing cyanide recovery techniques in their milling or heap-leaching plants, special precautions and monitoring procedures are employed to avoid contamination of the surrounding environment and to reduce the exposure of wildlife or humans to cyanide-laden process streams. In an emergency, chemical breakdown of cyanide can be induced quickly with chlorine gas.

Because of the danger of mercury pollution, the use of mercury amalgamation in domestic gold operations is now virtually nonexistent. The amalgamation process continues, however, to be used in an environmentally detrimental manner in some unregulated frontier mining operations in the Amazon Basin and in the Philippines. Mercury and arsenic can be natural contaminants of gold ores, requiring troublesome or costly extraction processes. Other potential pollutants that may be byproducts from gold mining include antimony, bismuth, tellurium, and thallium. Two iron sulfides, pyrite and pyrrhotite, commonly occur in gold deposits and can be a source of stream pollution as they oxidize to sulfates and other soluble compounds. Pollution resulting from some placer operations may be reduced or eliminated through the use of properly designed settling ponds. Waste dumps, mill tailings, and excavations are increasingly subject to public scrutiny, and control costs must be taken into account with other operating factors. Expanded mine safety requirements in recent years are another important cost factor.

Employment.—According to annual data prepared by the U.S. Department of Labor, employment in the Nation's gold mines and mills, exclusive of office employees, more than doubled from nearly 7,000 in 1985 to 15,000 in 1989. The number of jobs available in both surface and underground mines and associated processing plants is not always directly proportional to mine production, reflecting instead variations in development activity, the price of gold, weather, type of mining operation, etc. Citing employment studies for mining in Nevada and South Dakota, the Economics Institute of Boulder, CO.[16] derived an employment multiplier of 19.4 that, when applied to each $1 million of gold production, gave an estimate for total direct plus indirect employment attributable to gold production of about 51,000.

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[1] Ounce refers to troy ounce. One kilogram of gold weighs 32.1507 troy ounces.

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[11] Work cited in footnote 9.

[12] Values have been converted from South African rands (R) to U.S. dollars at the rate of R1.00 = US$0.3822 for 1989, as shown in Int. Financial Stat., V. 43, No. 5, May 1990, p. 478.

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[15] Work cited in footnote 9.

[16] Thomas, P. R. Gold Into the Nineties: Prospects and Challenges. The Economics Institute (Boulder, CO.). Paper presented at the Gold and Silver Institutes, Annual Meetings, Grand Cayman Island, Mar. 12–15, 1989, pp. 19–20.

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